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ABSTRACT

This publication is a compilation of original and republished materials from numerous individuals and organizations working on pesticide reform and integrated pest management (IPM)--using alternatives to prevailing chemical-intensive practices. The manual provides comprehensive information on implementing school IPM, including a practical guide to identifying, preventing, and controlling common school pest problems. It is designed for individuals who are responsible for school pest management. It includes information on why schools should adopt IPM programs, how to develop and implement a program, pest management strategies for structural pests, school IPM experts, a model policy and contract, a non- and least-toxic product guide, and fact sheets on the toxicity of commonly used pesticides in schools. (EV)

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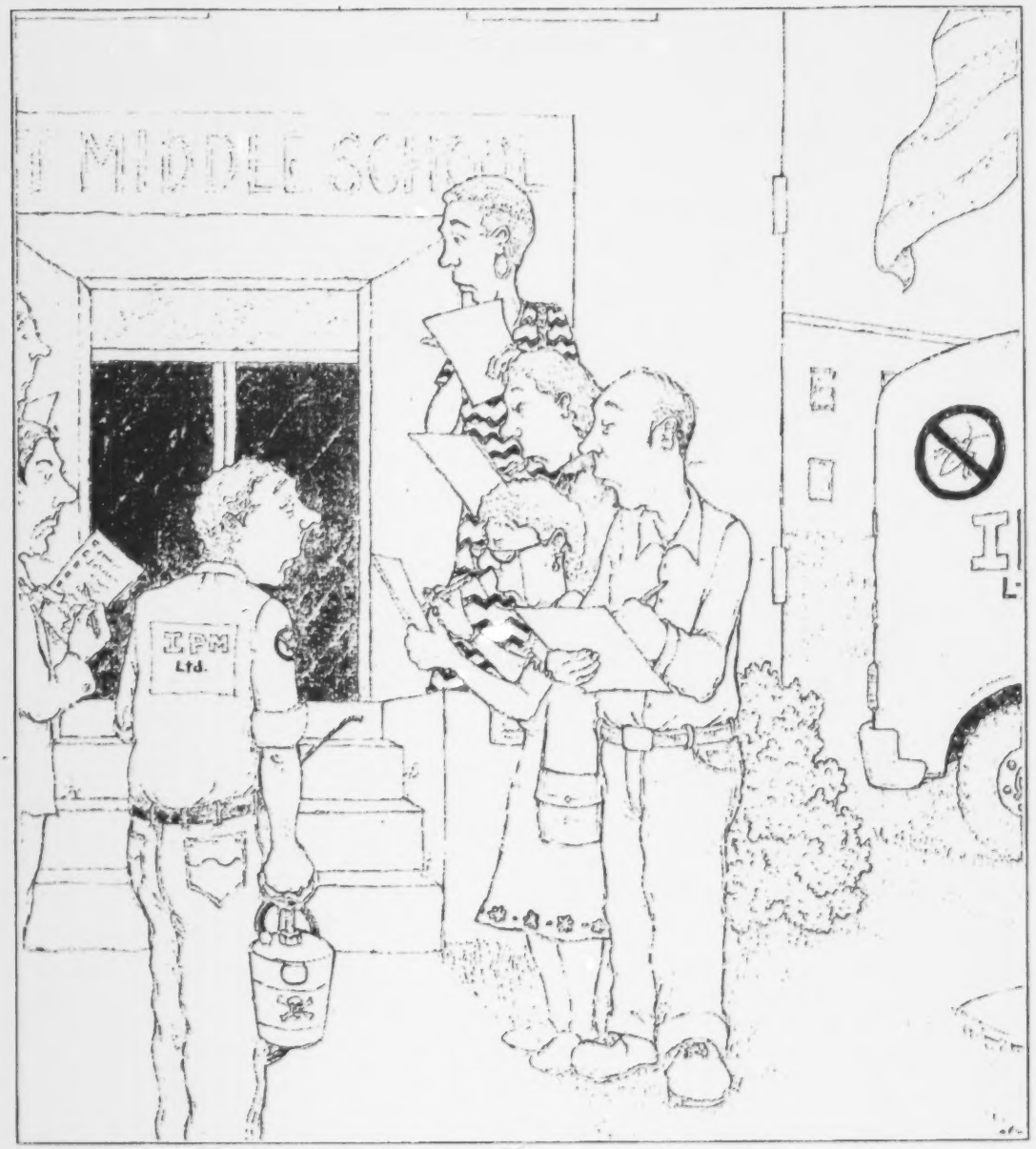

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Building Blocks for School IPM

A Least-toxic Pest Management Manual

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Building Blocks for School IPM

A Least-toxic Pest Management Manual

Edited by Becky Crouse, Public Education Coordinator and Kagan Owens, Program Director

April 2002

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Acknowledgement

Building Blocks is a compilation of original and republished materials from numerous individuals and organizations working on pesticide reform and integrated pest management. In addition to relying on extensive resources and file materials from Beyond Pesticides/National Coalition Against the Misuse of Pesticides, the editors would like to acknowledge the invaluable resources from the Northwest Coalition for Alternatives to Pesticides, the Bio-Integral Resources Center, and the Legal Environmental Assistance Foundation for their substantial contributions to this manual. Thank you to all organizations and individuals referenced on page 119, whose hard work and dedication has been both inspirational and educational to all.

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Section One

Implementing a School IPM Program

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I. USING THE SCHOOL IPM IMPLEMENTATION MANUAL

All across the country, communities are taking action to protect children from pesticide use in schools, establishing least-toxic pest management strategies through the adoption and implementation of local and state policies. This pest management program, which uses alternatives to the prevailing chemical-intensive practices, is called Integrated Pest Management (IPM).

IPM is a program of prevention, monitoring and control. It offers the opportunity to eliminate or drastically reduce pesticide use in schools, and to minimize the toxicity of and possible exposure to any products used. IPM mainly focuses on eliminating or reducing sources of food, water and harborage for pests, and limiting pest access into and through buildings. Education, in the form of workshops, training sessions and written materials, is an essential component of an IPM program for everyone — administrators, maintenance personnel, cafeteria staff, nurses, parents, and students.

Beyond Pesticides' ***Building Blocks for School IPM*** provides comprehensive information on implementing school IPM, including a practical guide to identifying, preventing and controlling common school pest problems. It is designed for individuals that are responsible for school pest management. Because schools in different parts of the country have different pest problems and different needs, this manual is intended as a guide that can be molded into a school IPM program for your area.

This manual includes information on why schools should adopt IPM programs, how to develop and implement a program, pest management strategies to structural pests, school IPM experts, a model policy and contract, non and least toxic product guide and fact sheets on the toxicity of commonly used pesticides in schools.

II. CHILDREN ARE VULNERABLE TO TOXIC PESTICIDES

The vulnerability of infants and children to the harmful effects of pesticides has attracted national attention. The U.S. Environmental Protection Agency (EPA), the National Academy of Sciences, American Public Health Association and the National Parent Teachers Association, among others, have voiced concerns about the danger that pesticides pose to children.

During any normal school day, children and school personnel are exposed to hazardous pesticides. Most schools do not have a written pesticide or pest management policy, and routinely apply pesticides in classrooms, gyms, playgrounds, cafeterias, and offices as their method of 'pest control.' With routine applications, pesticides are often applied needlessly and are frequently overapplied. When pest control is contracted out, school administrators or facility mangers often don't know which pesticides are being used in and around their school. And sadly, despite all of the evidence, most school administrators also don't know the harm these pesticides pose to children.

Pesticide exposure at school can occur whether applications are made before children enter the building or while they are present. Chemicals fill the air and settle on desks, counters, shades and walls. Children and personnel breathe in contaminated air or touch contaminated surfaces, unknowingly exposing themselves to residues that can remain for days and sometimes break down into other dangerous compounds.

Schools frequently provide an inviting habitat for pests. As school facilities age, their susceptibility to pest invasions increase, and established pest populations tend to expand. Infestations may indicate deficiencies in sanitation or structural disrepair. Roaches find good food stuffed away in forgotten lunch bags, head lice move freely from host to host where children and their clothing are kept close together all day, and weeds that prefer compacted soils out-compete native grasses on school athletic fields. Fortunately, learning to solve pest problems without chemical dependency also teaches students valuable lessons about health, their environment, and decision-making.

Most insect and weed pests may be a nuisance, or raise aesthetic issues, but they do not pose a threat to children's health. The public is increasingly calling into question the use of pesticides for cosmetic results alone. The unleashing of these toxic chemicals into our environment for aesthetic gain is responsible for countless cases of human suffering and untold environmental consequence. Children should never be exposed to potentially harmful pesticides for this reason. (See *Section Four -- Pesticides Used in Schools* for more information.)

Don't be misled by the pro-pesticide lobby. They'll have you to think that if we stop using toxic pesticides, disease-carrying pests and weeds will overcome our school buildings and lawns. This is simply not true. A school IPM program effectively prevents and manages pest problems -- without toxic pesticides.

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III. WHAT IS INTEGRATED PEST MANAGEMENT?

A good integrated pest management (IPM) program can eliminate the unnecessary application of synthetic, volatile pesticides in and around schools. The main elements of a good IPM program include: 1) monitoring, to establish whether there is a pest problem, 2) identifying the causes of the pest problem, 3) addressing the cause and changing conditions to prevent problems, 4) utilizing pest suppression techniques, if necessary, based on mechanical and biological controls, and 5) only after all non-toxic alternatives have been tried and exhausted, the use of the least-toxic pesticide.

An IPM program should include a written policy guide and an acceptable/prohibited materials list. Monitoring eliminates the need for scheduled pest control visits and thus the unnecessary use of chemicals. A successful school IPM program relies heavily on good communication between all school users and personnel.

Integrated Pest Management (IPM) Defined

IPM is a managed pest management system that:

(a) eliminates or mitigates economic and health damage caused by pests;

(b) minimizes the use of pesticides and the risk to human health and the environment associated with pesticide applications; and,

(c) uses integrated methods, site or pest inspections, pest population monitoring, an evaluation of the need for pest control, and one or more pest control methods, including sanitation, structural repairs, mechanical and biological controls, other non-chemical methods, and, if nontoxic options are unreasonable and have been exhausted, least toxic pesticides.

Least-toxic control products are an ever-expanding market. New materials and devices are increasingly available to private consumers and pest control professionals. Materials to consider after exhausting non-toxic methods include: boric acid and disodium octobrate tetrahydrate; silica gels; diatomaceous earth; nonvolatile insect and rodent baits in tamper resistant containers or for crack and crevice treatment only; microbe-based insecticides; botanical insecticides that do not contain synthetic pyrethroids or toxic synergists; biological, living control agents, such as parasites and predators; soap based products; and products that do not contain hazardous inert ingredients or contaminants listed on the pesticide label.

A key to cutting pest management costs is to look for long-term solutions, not temporary control, when addressing a pest problem. Pesticides don't solve the problems that have created the pest-friendly environment -- they only treat the symptoms of an infestation. They are often ineffective over the long term, and the most common pests are now resistant to many insecticides. Efforts need to be made to eliminate access to structures and remove food sources in order to eliminate a pest problem.

The Six IPM Program Essentials

Monitoring. This includes regular site inspections and trapping to determine the types and infestation levels of pests at each site.

Record-Keeping. A record-keeping system is essential to establish trends and patterns in pest outbreaks. Information recorded at every inspection or treatment should include pest identification, population size, distribution, recommendations for future prevention, and complete information about the treatment action.

Action Levels. Pests are virtually never eradicated. An action level is the population size that requires remedial action for human health, economic, or aesthetic reasons.

Prevention. Preventive measures must be incorporated into the existing structures and designs for new structures. Prevention is and should be the primary means of pest control in an IPM program.

Tactics Criteria. Under IPM, chemicals should be used only as a last resort, but when used, the least-toxic materials should be chosen and applied by methods that minimize exposure to humans and all non-target organisms.

Evaluation. A regular evaluation program is essential to determine the success of the pest management strategies.

State School IPM Programs

Sixteen states have state laws that recommend or require schools adopt an IPM program. There are an additional number of states (including Hawaii, Indiana, Oklahoma, Nebraska, North Carolina, South Carolina, Tennessee, Washington, and Wisconsin) that have developed materials to facilitate schools implement an IPM program.

STATE	*School IPM*
California	Recommends
Connecticut	Recommends
Florida	Requires
Illinois	Requires
Kentucky	Requires
Louisiana	Requires
Maine	Recommends
Maryland	Requires
Massachusetts	Requires
Michigan	Requires
Minnesota	Requires
Montana	Recommends
New York	Recommends
Pennsylvania	Requires
Texas	Requires
West Virginia	Requires

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Position Statements on School IPM

National Parent and Teachers Association Position Statement (adopted by the 1992 Board of Directors).

"The National PTA, long advocate for a healthy environment, supports efforts:

- at the federal, state and local levels to eliminate the environmental health hazards caused by pesticide use in and around schools and child care centers. These efforts will result in cost-savings when use of chemical controls is reduced; decreased health risks; and safer school and child care center environments.
- to encourage the integrated pest management approach to managing pests and the environment in schools and child care centers. Expansion of integrated pest management policies in schools and child care centers is an excellent long-term solution for control of pests that will significantly lower children's exposure to harmful chemicals by using the least-toxic mix of pest control strategies..."

American Public Health Association Healthy Schools Resolution (adopted in 2000).

"The American Public Health Association, ... recognizing the need to support global, federal, state, and local policies that promote healthy environments for children, that prevent exposures to environmental hazards, that provide for a parent right to know about hazards, ... therefore, APAH ... Supports [measures] that would require schools to follow least-toxic pesticide practices and provide prior notice to parents and personnel of certain pesticide applications..."

Schools Save Money with IPM

Because IPM focuses on prevention of the pest problem, and proper monitoring to determine the extent of the pest problem, school IPM programs can decrease the amount of money a school will spend on pest control in the long-term. Chemical-intensive methods, a symptomatic approach to managing pest problems, may only prove to be less expensive in the short-term. The long-term health of our children is not worth some short-term economic savings that just do not add up over time.

According to the U.S. Environmental Protection Agency, "Schools across the nation that have adopted such programs report successful, cost-effective conversion to IPM. IPM can reduce the use of chemicals and provide economical and effective pest suppression ... [P]reliminary indications from IPM programs

... suggest that long term costs of IPM may be less than a conventional pest control program."[1]

In a report entitled, *Pesticide Use At New York Schools: Reducing the Risk*, the Attorney General of New York State, Eliot Spitzer, says the following:

> We often hear that implementation of integrated pest management. . .can be expensive. Because it is easy to envision costs associated with establishing new policies and practices, re-training personnel and educating building occupants, this can be a powerful argument to school administrators trying to squeeze the most out of admittedly tight budgets. While the argument might have some initial appeal, experience tells a different story. In case after case, schools and other institutions have reduced their pest control costs early in the transition, often in the first year.[2]

The Washington State Department of Ecology has done a careful analysis of the costs of pest control that considers some of the "hidden" costs, such as regulatory compliance, waste disposal, insurance, and liability for health effects, environmental damage and compliance violations. The Washington report includes worktables that will assist school administrators to estimate and compare the costs of a conventional pest management program with the costs of an integrated pest management program. The report also features some revealing worksheets to help schools appreciate the costs represented by risk and future liability.[3]

Depending on the school's current maintenance, sanitation and pest management practices, some economic investment is usually required at the outset of an IPM program. Short-term costs may include IPM training, purchasing new equipment, hiring an IPM coordinator, or making preliminary repairs to buildings. Whether the pest management services are contracted out, performed internally by school staff, or both may also affect the cost of implementing a school IPM program.

Activities that can be absorbed into a school's existing budget include training of maintenance, cleaning and food service staff and educating students and teachers to modify their behavior. In addition, some school maintenance and structural repair funds may already be budgeted for activities such as replacing water-damaged materials, landscaping, waste management, and physical barriers.

Monitoring is critical to reducing pest management costs because it helps pest managers determine if, when and where pest populations warrant action and therefore requires more precise and strategic pest management approaches. For

example, instead of spraying the entire school building for a pest, monitoring may determine that the pest problem is concentrated in the food service area, thus decreasing the amount of resources needed to control the pest population. Without monitoring, conventional pest management spray programs tend to spend a lot of time spraying materials into all sites. Monitoring can also help determine if damage thought to be caused solely by pests, is actually caused by other factors poor drainage or leaky pipes.

The fact that pest control is not often a large part of the school's budget should not hinder the school's transition to an IPM program. It is not necessary for the entire school to be monitored, just those areas with the potential for a pest problem, leaving the other areas to be monitored and managed on a complaint basis. In addition, certain facets of an IPM program could be implemented over time in order to keep costs down. For example, Monroe County, Indiana school officials realized that they could not make the necessary structural upgrades for all their kitchen storerooms all at once. Since implementation of their IPM program in 1995, they have made the conversion, with only one storeroom remaining.

Examples of IPM as an Economical Approach to Pest Management

Across the country, schools and communities that are currently using IPM strategies indicate that a well-managed IPM program is saving them money. Following are just a few examples.

- A school board member in Illinois has stated that "most [of the] schools utilizing IPM strategies [in his school district state] that IPM does not cost more, it just costs differently. Thus, a school having a problem with mice might install door sweeps to deny access instead of continuously allocating funds for a pest control professional. Additionally, an IPM program need not be burdensome with regard to personnel. Typically, it will require some light training, and it then integrates seamlessly into existing roles and responsibilities."[4]

- The Boulder Valley School District in Colorado has saved thousands of dollars for pest management after hiring a company that has successfully controlled the schools' pest problems with the implementation of an IPM program that does not use any toxic pesticides.[5]

- Before Monroe County Schools in Bloomington, IN implemented an IPM program in 1995, it was spending about $34,000 on pest management. With the hiring of an IPM Coordinator in 1997, and spending less than $1,000 per

year on products, the school district is saving around $13,600 a year in pest management.[6]

- A survey of 21 Pennsylvania school districts found that 81 percent were able to control pest problems using IPM with little or no change in costs.[7]

- At Vista de las Cruces School in Santa Barbara, California, pest management was contracted out with a pest control company for $1,740 per year for routine pesticide applications. After the school switched to an IPM program, their costs were reduced to a total of $270 over two years.[8]

- A school in Susquehanna, New York implemented an IPM program after students were poisoned from a pesticide misapplication. The school engineer states that they have cut costs by more than $1,000 per year "and the turf looks better than ever."[9]

- Mt. Lebanon School District in Pittsburgh, Pennsylvania's IPM program is "manageable and no more expensive than using pesticides." The school district has implemented their IPM program since 2000 "at a relatively low cost with improved playing surfaces."[10]

- A well-known example of school IPM is the Montgomery County, Maryland public schools. The IPM program in Montgomery County covers 200 sites used by over 110,000 students and 12,000 employees. Although German cockroaches are the biggest problem the county faces, they also manage rodents, termites, and stored food pests. The county successfully reduced pesticide use from 5,000 applications in 1985 to none four years later, saving the school district $1,800 per school and $30,000 at the food service warehouse.[11]

- In another county in Maryland, the Anne Arundel School District reduced its pest control budget from $46,000 to $14,000 after its first year of IPM implementation.[12]

- An IPM program at the University of Rochester resulted in a 50 percent reduction in material costs and a substantial reduction in personnel costs.[13]

- The City of Santa Monica, California's IPM program for the city's public buildings and grounds reduced the cost of pest control services by 30 percent.[14]

- Albert Greene, Ph.D., National IPM Coordinator for the U.S. General Services Administration, has implemented IPM in 30 million square feet, approximately 7,000 federal buildings, in the U.S. capital area without

spraying toxic insecticides. Dr. Greene states that IPM, "can be pragmatic, economical and effective on a massive scale."[15]

Pests can be managed effectively and economically without toxic chemicals through the implementation of an IPM program. To institutionalize these practices, schools should enact policies that provide for the use of IPM practices for managing pest populations with the least possible hazard to people, property and the environment.

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[2] Spitzer, E. 2000. *Pesticides Use at New York Schools: Reducing the Risk*. Environmental Protection Bureau, Attorney General of New York State, p.20.

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[7] Wendelgass, B. 1997. *Evaluation of Integrated Pest Management Use in Pennsylvania School Districts*. Clean Water Action and Clean Water Fund. Philadelphia, PA.

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[9] Safer Pest Control Project. 1998. *Cost of IPM in Schools*. Chicago, IL. *Citing* Angelo Ranieri. 1998. Building Engineer, Susquehanna, NY. Personal Communication.

[10] Smartschan, G.F. 2000. Superintendent of Schools, Mt. Lebanon School District, Pittsburgh, PA. Letter to U.S. Senator James Jeffords.

[11] Schubert, S. et al. 1996. *Voices for Pesticide Reform: The Case for Safe Practices and Sound Policy*. Beyond Pesticides, National Coalition Against the Misuse of Pesticides and Northwest Coalition for Alternatives to Pesticides. Washington, DC.

[12] Washington State Department of Ecology. 1999. *Calculating the True Costs of Pest Control*. Publication No. 99-433. Olympia, WA.

[13] Spitzer, E. 2000. *Citing* Castronovo, P. 1999. Personal Communication. University of Rochester.

[14] Washington State Department of Ecology. 1999. *Citing* U.S. EPA. 1998. *The City of Santa Monica's Environmental Purchasing – A Case Study*. EPA 742-R-98-001

[15] Greene, A. 1993. "Integrated Pest Management for Buildings." *Pesticides and You* 13(2-3). Washington, DC.

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IV. DEVELOPING A SCHOOL IPM PROGRAM

A written policy statement will serve as guide in the development of an IPM program and establish procedures for conducting the pest control program. It is critical that schools adopt an official school IPM policy, even if the school already has a good program without a written policy. This official policy is especially important when students, whose parents were directly involved, graduate or there is turnover in personnel responsible for the program, potentially leading the school to backslide on its program.

It is essential to create an IPM decision-making process that draws on accurate, timely information. Sanitation, solid waste management, landscape, structural maintenance, and occupant education are essential components to an IPM program. Following are some general elements that should be part of the school IPM policy. Beyond Pesticides' model policy can be found in the Addendum.

Training. Training of school personnel is critical to the success of an IPM program. All personnel and contractors, including facilities personnel, principals, teachers, parents, students and the public, have roles and responsibilities in carrying out the IPM program.

Pest Action Threshold. A pest action threshold is a tolerance level determined by the sensitivities of the building's occupants, and should reflect the pest management objective for the site. This means that action will only be taken when pest populations exceed action thresholds. Precise recommendations or actions to achieve specific results are an essential part of the IPM program. Specific recommendations, including an explanation of the benefits, should be based on the evaluation of all available data obtained through monitoring. This will vary depending on the site – what type of structure it is, who is using it, and how it is being used. For instance, cafeterias will need to be more pest free than the equipment room. This decision should be made by someone knowledgeable about the pest in need of control and the risks of pesticides -- someone who does not have a financial interest in selling a pesticide product.

Inspections. Monitoring and record keeping help identify the nature and extent of a pest problem. Implement a monitoring program designed to provide accurate, timely information about pest activity – to establish whether there is in fact a pest problem and to identify its causes. Implement a schedule and a plan for monitoring pest populations and the success of pest control efforts. This will help determine acceptable pest population levels, effective reduction measures, and breach of the action threshold. The best way to monitor for many pests, like cockroaches, is with sticky traps placed throughout the school structures at many different levels. Traps should be set for 24 hours, and the results recorded. The entire school facility should be inspected at least bi-annually for pest problems.

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Specific sites with the highest potential for pest problems should be monitored monthly, such as food service areas, cafeterias, bathrooms, and storage areas.

Pest Prevention Practices. Analyze the conditions causing the pest problem and devise ways to change those conditions to prevent or discourage recurrence of the problem. Methods can include modifying the environment to decrease the effectiveness of the pests' breeding, feeding, or shelter habitat and using pest-resistant or pest-free varieties of seed, plants and trees. Eliminate the need for hazardous pesticides by changing conditions that invite pest problems, including occupant education, careful cleaning, pest-proof waste disposal, and structural maintenance. Learn about what the pest requires to live -- food, water, and habitat -- then reduce sources of food and water, and modify the habitat. For instance, always clean up food and food areas, place food in airtight, sealed containers, dispose of food and food wrappers in sealed garbage containers, repair leaky pipes and faucets, caulk cracks and crevices, and eliminate clutter. Remember, it can take some time for these methods to be effective.

Mechanical, Biological, and Least-Toxic Controls. If all other methods have failed, and monitoring shows that your pest population is still above your action thresholds, use a combination of strategies to directly suppress pest populations. Focus on mechanical traps, such as sticky traps, and living biological controls, including pheromones, parasitic insects, predators and disease. Only when these strategies have proven ineffective should you choose a least-toxic chemical control strategy, and only then through spot treatment with the least toxic pesticide possible. Carefully weigh the risks associated with pesticide use against the problems caused by the pest. Consider your options carefully, being mindful not to jump at a solution that may have risks without first collecting the facts.

If you must use a pesticide, you should the least toxic pesticide available. Boric acid, formulated from a natural mineral, is an effective ant and cockroach stomach poison. When properly applied, it has a relatively low toxicity compared to other pesticides. Further, it does not evaporate into the indoor air of the structure, unlike many other pesticides. Look for boric acid that has less than one percent of inert ingredients, therefore you have a better idea of what you are applying and its risks than with most other pesticides. While boric acid is somewhat slower acting than other materials, it is highly effective over a long period of time. But remember, all pesticides are poisones designed to kill, and should be handled carefully and with respect. Boric acid should be applied only in areas where it will not come in contact with people – cracks and crevices, behind counters, and in baseboards. Applicators should wear protective clothing, gloves, and a filter mask.

Acceptable materials. The policy should establish a list of acceptable materials to be introduced after other methods have proved ineffective. These materials include:

(a) boric acid and disodium octobrate tetrahydrate,
(b) silica gels,
(c) diatomaceous earth,
(d) nonvolatile insect and rodent baits in tamper resistant containers or for crack and crevice treatment only,
(e) microbe-based pesticides,
(f) soap based products,
(g) pesticides made with essential oils (not including synthetic pyrethroids) without toxic synergists,
(h) pesticides listed under 25(b) of the *Federal Insecticide, Fungicide, and Rodenticide Act* (section 152 of title 40, Code of Federal Regulations), and
(i) Products that do not contain inert ingredients categorized as "List 1: Inerts of Toxicological Concern" or any equivalent EPA classification

School IPM Committee. If the need is established to move beyond the acceptable materials to utilize insect growth regulators, botanicals (pyrethrins and synthetic pyrethroids) or other EPA toxicity category III and IV pesticides, an independent review committee should be established to review the program and the proposed uses. Parents, students, teachers, and community members should be allowed to participate on the school IPM committee.

Pesticide Use Restrictions. Limiting when and what pesticides are applied in and around schools is important to the reduction of pesticide exposure. Pesticides should never be applied when students or staff are in the area or will return within 24 hours of the application. Certain toxic pesticides, such as:

- a pesticides determined by EPA to be a likely, probable, or known carcinogen, mutagen, teratogen, reproductive toxin, developmental neurotoxin, endocrine disrupter, or immune system toxin;
- a pesticide in EPA's toxicity category I or II; and,
- any application of the pesticide using a broadcast spray, tenting, fogging, or baseboard spray application.

Public Right to Know. Notification should include the common and trade name, a description of the potential adverse health effects based on the chemicals Material Safety Data Sheet, a description of the location and reasons for the application of the pesticide, and who to contact for more information. Written notification prior to each pesticide use in the schools is a good way to make sure that *all* parents, children and staff are aware and warned. Prior notification should be 72 hours in advance to make sure the information has been received, to get further information regarding the pesticide and to make arrangements to avoid the exposure, if necessary. It is also important to post notification signs 72 hours prior to the application. The signs should remain posted for 72 hours following the application, because of the residues left behind after an application.

V. ESTABLISHING RESPONSIBILITIES IN IMPLEMENTING SCHOOL IPM

A successful IPM program will require a firm commitment from those responsible for overseeing pest management, whether it be done in-house or contracted out. An IPM program will only be as strong as the commitment of those involved. All school users and employees play a role in ensuring the school IPM program is successful.

School IPM Coordinator

The school district or school should appoint an IPM coordinator who is a school employee and is trained in school IPM. This person should be responsible for (adapted from the Legal Environmental Assistance Foundation):

- Regularly monitoring pest activity and maintaining records of all pest control services through the use of a Pest Activity log and IPM log that is accessible to all building occupants and contractors.
- Inspecting the inside and outside of school properties regularly to identify problem areas or personnel practices that are contributing to pest infestations.
- Developing a plan to correct structural deficiencies that includes a detailed list of deficiencies and corrective actions.
- Initiating requests for minor maintenance.
- Initiating new sanitation methods to insure that food is properly stored in sealed containers, and all areas where food is prepared or consumed and the ground around dumpsters is thoroughly cleaned at the end of each day.
- Scheduling and facilitating IPM Committee meetings.
- Coordinating School IPM training for all school district staff, students, parents, and the public.
- Ensuring accurate identification of school pests.
- Working with school staff to gather information about pesticide or pest-related health and safety issues.
- Overseeing IPM contractors or staff engaged in monitoring pest problems and pest management actions.
- Working with schools to carry out posting and notification and record keeping.
- Ensuring that pest information and sightings are properly handled.
- Presenting an annual report to school district evaluating the progress of the School IPM program.
- Coordinating volunteers and staff in various School IPM projects.
- Coordinating School IPM awareness and education programs, by working with schools to identify and carry out ideas for student or community involvement in the School IPM program, and encouraging schools to institute environmental health programs within the curriculum.

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School IPM Committee

The IPM Committee should approve the School IPM Policy, develop implementation guidelines and oversee implementation of the IPM policy. The IPM Committee will include parents; students (if age appropriate); teachers; school administrators; representatives from the administration; facilities, food service and landscape staff; any pest control company or companies contracted by school district to manage pests; and community environmental and public health organizations. The IPM Committee should be responsible for (adapted from the Legal Environmental Assistance Foundation):

- Developing an implementation plan, including guidelines for inspection, monitoring, record keeping, reporting, certification, School IPM training, and evaluation of the School IPM program.
- Making recommendations for long-term site planning and pest prevention.
- Setting and revising pest injury and action levels to determine when a pest population at a specific site causes unacceptable economic or medical damage and requires corrective action.
- Reviewing pesticides for toxicity and health effects.
- Analyzing life cycles and patterns of pest species.
- Developing guidelines for notice, posting and appeals.
- Developing education and awareness programs for staff and students.
- Developing resource list of those parents and community members with special skills that could contribute to the School IPM program and who are volunteers willing to implement the program.
- Developing guidelines for emergency decision making and limited use exemptions.
- Reviewing progress in controlling pests through documented integrated methods.
- Reviewing and recommending action to school district in response to parental, staff or neighbor requests for reconsideration of planned pesticide use.
- Reviewing and recommending authorization or denial of pesticide use proposals by pest control contractors.
- Developing and annually reviewing pest prevention and treatment guidelines to ensure they are based on the best available prevention techniques.

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School Maintenance and Custodians

If pest management is done in-house, this may include maintenance and custodians to implement some, if not all, of the IPM strategies. If pest management is contracted out (see model school IPM contract in the Addendum), the pest management company will recommend that custodians, school maintenance workers and facility managers to make habitat modifications, building repair, and sanitation improvements. The school maintenance and custodians should:

- Receive regular training in school IPM techniques.
- Report pest sittings to appropriate personnel.
- Ensure that school occupants take measures to prevent and help alleviate, rather than aggravate, pest problems.
- Be familiar with common school pests and signs of pest problems, and carryout recommendations made by the IPM coordinator and/or school pest management contractor.
- Store mops, sponges, and cleaning rags in a manner that will allow them to dry as quickly as possible.
- Clear and clean clogged gutters and drains, fix leaking pipes and dripping faucets immediately.
- Repair broken windows, screens, holes in building walls or doors.

Food Service Staff

Food service personnel must institute practices that minimize the availability of food and water to insects and rodents. They should:

- Regularly empty garbage and not allow it to overflow.
- Keep garbage away from building entrances and windows.
- Properly store food in thick plastic containers or metal containers with tight-fitting lids.
- Immediately clean up food that has spilled from tears or ruptures in sacks or containers.
- Be able to identify pests and report any siting to the appropriate personnel.
- Attend IPM training sessions.
- Inspect all incoming goods for signs of insect infestation.
- Inspect food service areas at least twice a month.
- Report any repairs needed to pipes, garbage disposal units, drains, etc..
- Keep the food service areas clean.

School Administrators, Teachers, Students and Parents

School staff and students play a key role in keeping the school facilities clean and pest-free, and reporting pest sittings. Staff and students should:

- Clean up litter and crumbs or drinks that have spilled.
- Place all waste in appropriate trash and recycle bins.
- Eat and drink in designated areas only.
- Report pest sittings to the appropriate school personnel.
- Incorporate principals of IPM in education materials in classes.
- Allow students to monitor and inspect school facilities for pests.
- Keep food in tightly sealed plastic containers.
- Report maintenance problems to the appropriate school personnel.

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VI. Structural Pest Management Strategies: an IPM Checklist

Successful implementation of IPM is based on altering the three elements that lead pests to the school building: entry, food and climate. Schools should make all efforts to perform the following steps, which will result in decreased or elimination of the pest problem and prevent future outbreaks from occurring.

Entry Restrictions

Simple measures can be made to restrict the access pests can use to get into the school buildings including:

- Install and repair screens on windows and doors.
- Install weather stripping around windows and doors.
- Seal off all gaps and openings between the inside and outside of buildings, i.e. caulk, paint, sheet metal, steel wool, spray foam insulation, cement or screen openings around all window frames, cables, pipes, vents, duct work, exhaust fans, utility wires and conduits. (Priority should be made to those areas leading to and from kitchen areas, cafeterias, bathrooms, and storage.)
- Inspect incoming products for insects.
- Install screen covers over floor drains.
- Keep doors closed at all times.
- Trim vegetation (ivy, shrubs and trees) at least one foot away from building.
- Remove clutter around the building's structure.
- Replace bark mulch with gravel or stone or keep bark mulch a minimum of one foot away from the building.
- Screen all intake and out-take vents.

Eliminate Food Source

Proper sanitation is essential in reducing the availability of food to which pests are attracted. Inspections of all food preparation and storage areas, cafeterias and eating areas should be made monthly.

- Vacuum and mop regularly.
- Empty trash daily -- cafeteria trash should be removed just after lunch break and at the end of the day. Trash cans should have tight fitting lid and a plastic liner.
- Clean cafeteria tables, chairs, floors, and countertops just after lunch and again at end of the day's use.
- Make sure no dirty dishes are left in sinks, countertops, etc.
- Store pet food in pest-proof containers (tight fitting lids and made of thick plastic, glass or metal).
- Seal or refrigerate food.

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- Replace decaying wood.
- Keep garbage cans and dumpsters away from doorways and other high traffic areas.
- Empty and wash out (with detergent and hot water) recycling bins at minimum daily, if not more frequently.
- Store recycled products in bins with tight fitting lids and send them to the appropriate recycling facility at least weekly.
- Allow food and beverages in designated areas only.
- Prohibit food and beverages in classrooms.
- Do not store paper goods in same area where food and trash is kept.
- Clean food preparation and kitchen areas throughout day.
- Remove grease accumulation from ovens, stoves, vents regularly.

Habitat Control

- Repair leaking pipes and plumbing.
- Insulate hot and cold water pipes.
- Use dehumidifiers in areas of high moisture.
- Remove and replace water-damaged material.
- Clean floor drains, strainers and grates regularly.
- Eliminate shelf paper.
- Install vapor barriers.
- Ensure adequate ventilation.
- Store food, paper products and cardboard boxes at least 12 inches off the floor, and not touching walls or moist areas.
- Keep food and paper products in tightly sealed containers.
- Store products on metal, not wood, shelves.
- Immediately clean, dry and store mops after each use.
- Maintain adequate drainage away from buildings.
- Empty buckets of any water before storing.
- Where possible, install low pressure sodium vapor bulbs which emit yellow light away from buildings and direct them towards the building.

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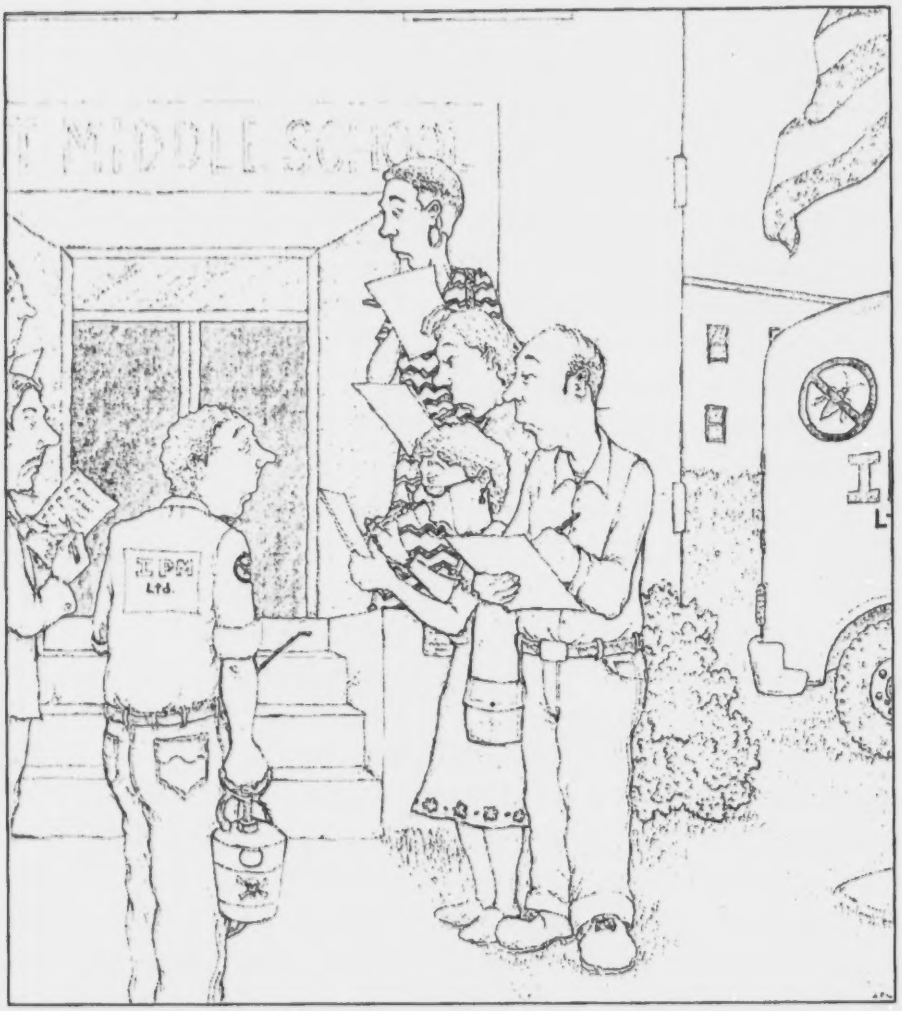

Section Two

IPM Strategies for Common School Pests

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ANT MANAGEMENT

IDENTIFICATION

Name	Description/ Queens	Foraging Behavior	U.S. Distribution/ Bites/Stings
Acrobat	Light brown to black, larger than average (2.5-4 mm); nest inside in foam Single queen	Sweets and honeydew; can raise heart-shaped abdomen over head New colonies by mating flights	Native-TN, AR, throughout US Sting and bite
Argentine	Light to dark brown; average size (2.2-2.8 mm); nest outside in ground under boards, stones and concrete Multiple queens	Prefer sweets and honeydew, but omnivorous; forage in lines	Seen mainly in WA, OR, CA, MD, west to IL, TX, AZ, Mexico, HI, S. America, Europe, S. Africa, Australia Do not sting or bite
Crazy	Dark brown to black; average size (2.2-3 mm); Nests outside in soil, inside in potted plants and wall voids Multiple queens	Sweets and kitchen scraps; follows no trail	Mainly in AZ and Gulf States Do not bite or sting
Ghost	White gaster and legs, black head and thorax; tine (1.5mm); nests inside containers, behind baseboards, outside in soil Multiple queens	Sweets and grease; trails hard to see	Tropic ant; number one household ant in Southern FL; seen in HI and CA Do not bite or sting
Little Black	Black; tiny (1.5-2 mm); nest outside in soil, inside in wall voids and cabinets Multiple queens	Sweets and grease; omnivorous; forages in trails	Northeast, Midwest, TN to TX Do not bite or sting
Odorous House	Brown to black; 2.4-3.2 mm; nest outside or in wall voids; pungent "rotten coconut" odor when crushed Single queens	Prefer sweets and honeydew, but omnivorous; forage in lines	Native to U.S.; wide distribution Do not bite or sting
Pharaoh	Reddish brown; tiny (1.5-2mm); nest inside or in any secluded spot Multiple queens	Sweets and omnivorous; found in packages; gets under bandages	Found throughout U.S. Do not bite or sting
Thief	Yellow to dark brown; tiny (1.8 mm); nest inside walls and kitchen cabinets, or outside with other ants	Prefer meat and cheese; eat sweets; forage in trails; confused with pharaoh ants	Found throughout U.S. Do not bite or sting

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INDOOR ANTS

IDENTIFICATION/HABITAT

See the ant identification box for common house-invading ant varieties.

PREVENTION

Ants, other than Pharaoh ants, observed indoors are probably coming from outside. They usually follow distinct chemical trails that they have left to easily find their way from their point of entry to their food source.

Structural

- Follow the ant trail, identify the points of entry into your home, and seal them out. If you don't have a clear ant trail, place small pieces of cardboard or wax paper with syrup or a high-protein treat (depending on your ant type) out at night. In the morning, there should be a thick ant trail leading to their doorway(s) into your home.
- Caulk or screen all entry points. Drawing a solid line with regular chalkboard chalk, putting down lines of cayenne and black pepper as repellants, or using toothpaste, petroleum jelly or duct tape as sealants will work temporarily. For permanent sealing, use silicone caulking.

Cultural

- Clean up and remove food sources. Keep kitchen counters, stove tops and floors clean, put garbage in tightly sealed containers and empty it daily, and thoroughly rinse recyclables.
- Store sugars, grains and pet food in glass jars with seals or gaskets and plastic containers with tight-fitting lids. Ants can climb up the threads of screw-top jars and get in if there is no gasket or liner.
- Place pet bowls in moats – a pie tin filled with plain soapy water and the food bowl placed in the middle can be effective in preventing ant access, but be sure your pet won't drink the soapy water.

Biological

- Ants feed on "honeydew," a sweet substance produced by insects that feed on plant sap, such as aphids and scale. Control these insects and cut branches back from your house to prevent ant problems.

MONITORING

Ant infestations are typically detected via sightings at one or more of their sources of food.

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CONTROL

NON-TOXIC

- Apply one of the various, commercially available **sticky barriers** to foundation walls or the legs of tables or plant stands where ant problems are brewing.

- Use a **food attractant** placed in a dirt-filled, clay flowerpot to lure the ants away from your house; once they've moved in, kill them with boiling hot water.

- For a quick fix, sprinkle **corn meal** around the outside of your home. It will make the ants thirsty, they will go for water, swell up and explode.

LEAST-TOXIC

- **Soapy water** in a spray bottle or on a sponge will kill individual ants and erase the chemical trail that lines of ants follow.

- **Desiccating dusts,** such as diatomaceous earth and pure amorphous silica aerogel, kill ants by causing them to lose moisture and die. Diatomaceous earth must be garden/food grade. Place the dust in wall voids or cracks and then seal them, or sprinkle powder lightly around the edges of carpeted areas or brush it into the carpet, wait three days, and then vacuum. In cracks, the dusts can be effective for many years, as long as they are kept dry. Once-a-year applications to carpets should suffice. **When using either desiccating or boric acid dust, always wear a dust mask and goggles and cover any electronic equipment that could suffer dust damage. Do not use diatomaceous earth if you have lung problems.**

- **Boric acid** products, such as Drax™, are effective against Pharaoh ants. Create your own bait by mixing one teaspoon 99% pure boric acid with 1/3 cup apple-mint jelly. Place small dabs of bait in areas where you have seen ant activity and along established ant trails, but do not block the trails. Put out one to three dabs per 25 square feet, checking the baits every 1-3 days, and replacing any that have been eaten or adding a few drops of water to those that have dried out. Another effective bait mixture is 4 tablespoons of peanut butter, 6 tablespoons of honey and ¾ teaspoon boric acid. This bait will be especially effective if you are dealing with sugar and protein loving ants, or aren't sure of your ant variety. **Always be cautious with boric acid and keep away from children and animals.**

OUTDOOR ANTS

IDENTIFICATION/HABITAT

See the ant identification box for common house-invading ant varieties.

PREVENTION

Ants outdoors are normally not a problem. These ants actually benefit us by preying on flea and fly larvae, recycling organic matter, and aerating soil.

- If outdoor ants do become a nuisance, eliminate their food source by cleaning all spills and storing garbage in tightly fitted containers.
- Do not leave pet food out for long periods of time. When it is exposed, place the bowl in a tray of water. This moat will detract ants. Adding soap to this water will be more effective, but be sure your pet won't drink it.
- Ant populations may bloom because of the surrounding vegetation or groundcover. Cleaning and cutting back vegetation will make it less attractive to ants.

MONITORING

Ant infestations are typically detected via sightings.

CONTROL

NON-TOXIC

- Ants feed on "honeydew," a sweet substance produced by insects that feed on plant sap, such as aphids and scale. Controlling these insects may help control your ant problem.

- Drive ants out of flowerpots and outdoor nests by flooding them repeatedly.

- To directly control outdoor ants, digging up the colony will destroy it. This is very labor intensive.

LEAST-TOXIC

- Soapy water can be used to drench outside nests, killing some ants and forcing the others to relocate.
- Pour boiling or soapy water down the hole of the nest.
- Only if the nest is located in a dry area should boric acid be used. Sprinkle it around the openings. **Always be cautious with boric acid and keep away from children and animals.**

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ANT MANAGEMENT — CARPENTER

IDENTIFICATION

Carpenter ants are important decomposers of decaying trees in forests, but, as one of the most efficient wood-destroying insects in the US, in our homes they are damaging, expensive pests.

Carpenter ants come in a variety of sizes and colors. They range from ¼ - ½ inch (7-15 mm) long and can be red, red and black, or all brown. They have two distinguishing characteristics: they have only one node between their thorax and abdomen, and their thorax is evenly rounded in profile, with no spines.

The damaged wood in carpenter ant nests has smooth, clean galleries that feel as if they have been polished with fine grit sandpaper. There will be no frass, sawdust, mud, mastic or any other debris in the nest. The galleries normally follow the grain of the wood and are excavated in the softer portions, with connecting passages through the harder wood. The galleries are wide and irregular in shape, and often have rounded edges. Carpenter ants often have multiple nest sites.

Unlike termites, which burrow into the wood to feed upon it, ants burrow only to construct their nests. Nests are often kept clean by ants pushing wood bits and other debris out of the nest through a crack or slit, called a "window," into a dump pile of "frass." Carpenter ants have distinctive dump piles. Since they are simply excavators, their frass is mostly small, irregular piles of wood and look very much like sawdust. The frass will also contain ant feces, bits of soil, gravel and other debris, leftover pieces of their food – seed coats and the indigestible parts of other insects, and dead carpenter ants.

HABITAT

Carpenter ants will usually nest in water-damaged or softened, decaying wood – where there have been plumbing leaks, where wood has been repeatedly soaked by rain or condensation or where wood meets soil. They often begin their nests in decayed wood and then move to dry, sound wood. They can also nest in insulation, small voids or hollow doors.

PREVENTION

Structural

- Reduce moisture within the structure.

- Repair all roof and window leaks. Adequately ventilate damp areas such as basements and crawl spaces..

Cultural
- Properly grade soil around the home to drain water away from the structure.
- Prune tree and bush branches so they are not against the house walls.

Biological
- When doing repairs or creating new structures, use a naturally resistant wood such as cedar, cyprus or jarrah.

INSPECTION

- Watch the ants to find the location of their nest. Use jelly or honey as bait to find entrances in walls.
- Ascertain the extent of the infestation. You can hire a pest control company to do this, but make sure you are not obligated to enter a treatment contract along with the inspection.
- You can also conduct your own inspection. Use a flashlight to inspect the entire structure. Look for signs of wood boring activity such as sawdust, cracks, holes and mildew, as well as frass (insect droppings).
- Use a screwdriver to carefully probe suspicious looking hollow places.
- Determine if the infestation is active. How fresh are the frass and sawdust? If you spot live ants, you definitely have an active infestation

CONTROL

NON-TOXIC

- Since carpenter ants can only survive in a narrow temperature range, **manipulation of the temperature** provides a non-toxic control. Various pest control companies may offer to tent and heat the house or provide an alternative freezing method.

LEAST-TOXIC

- **Boric acid** applied to cracks and crevices or blown into wall voids through small holes drilled into the walls provide a least-toxic alternative for control. **Use boric acid with care, and keep it away from children and pets.**

- Desiccating dust, such as diatomaceous earth or silica gel can be blown into voids through small holes drilled into the walls. Be sure to choose a dust that is not mixed with a pyrethrin. Dusts placed in wall voids or cracks and sealed

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can be effective for many years if they are kept dry. **When using desiccating or boric acid dust, always wear a dust mask and goggles and cover any electronic equipment that could suffer dust damage. Do not use diatomaceous earth if you have lung problems, as it can cause respiratory irritation if inhaled.**

ANT MANAGEMENT – FIRE ANTS

IDENTIFICATION

There are a variety of fire ants living in the U.S.

The red imported fire ant is up to ¼ inch (6 mm) in length, reddish in color, nests in mounds 1-2 feet (0.3-0.6 m) in diameter and 1-½ feet (0.45 m) high, and has a painful sting. It is found in southern North Carolina through Texas.

The imported fire ant can range in color from yellowish-red to black. It is 1/10–1/4 inch (2.5-6 mm) in length and has sharply incurved mandibles. Imported fire ants are highly predacious, especially on fly larvae, have painful stings, and nest in large mounds. They are found in South Carolina and Florida to Texas, south to Costa Rica, Brazil and Peru.

The southern fire ant is brownish red with a brown to black abdomen and head, is 1/16–½ inch (1.5-6mm) in length and has a painful sting. It can nest in house structures (fireplaces, foundations, rotted wood) and its nest consists of loose soil with craters 2 feet square. The southern fire ant is found on the Gulf Coast and from the Carolinas to California.

Fire ants spread naturally by either moving existing nests or producing winged reproductives that mate in the air. The average colony can produce about 4500 sexual reproductives each year. Reproductive flights occur on warm days after rain; there is a coordinated release of males from large numbers of nests over a wide area. Workers open holes in the top o f the mound from where the males emerge and then park at altitudes of 295-984 feet (90-300 m). Virgin queens are released about 1 hour later, fly up to the males, mate quickly and then fly to a new location to start a new nest. Queens can fly up to 12 miles from their mother colony. When they land, they lose their wings, burrow into the ground and start laying eggs. The queen will lay 75-125 eggs in one to two weeks, and then stop laying eggs until the new workers have been reared to a functional level, about 24-30 days. She feeds the first batch of workers from food stored in her body. The small workers burst from the brood chamber and start foraging for food to feed the queen and new larvae. The new colony will contain several thousand workers and be a visible mound within six months.

Fire ants will eat anything. They usually eat ticks, insect larvae, ground dwelling insects and earthworms, but also feed on honeydew and exacerbate problems

with aphids and other homopterous insects. Oil is also a favorite food, making fire ants a pest of seeds. They also prey on corn and soybean crops, buds of beans, citrus, berries and okra, cabbage and Irish potatoes. They interfere with field workers and can kill or blind young farm animals. They prey upon some beneficials, such as ladybugs and ground beetles, but also pest insects like the boll weevil, tobacco budworm, soybean looper, velvetbean caterpillar, southern green stinkbug and pest flies.

HABITAT

Fire ant mounds are relatively large, about 1.5 feet high (.46m) and 2 feet wide (.6m). In marshy terrain or clay soil, they can be up to twice this size, while they may be smaller in sandy soil. Each colony contains 50,000 to 230,000 workers. Foraging tunnel entrances and exits extend outward from the mound for several yards, and the tunnels are about 4 inches deep and can be up to 132 feet long. Underneath the mound, there are interlocking tunnels and galleries where the ants live, with tunnels built downwards to the water table. Tunnels themselves have no visible openings except when the winged reproductives are released.

Fire ants cannot hear airborne sounds, but are highly sensitive to ground vibrations. When the mound is disturbed, ants boil out of the foraging tunnels, attacking anything that moves with a painful sting. Though mounds are important fire ant signs, they can also nest in structures, logs and under sidewalks. Changes in mound temperature cause fire ants to move the queen and larvae. In the summer and cool mornings, the queen is near the top of the mound where it is warmer. As the day heats up and during cold weather and droughts, the queen retreats to the protection of the lower galleries.

Though fire ants prefer to nest outside, they can nest indoors next to foundations and build termite-like mud tubes to enter cracks in a wall. They have been found nesting in wall voids, under rugs, in boxes in the attic and in clothes in drawers. They enter homes through holes around plumbing and by following electrical wires from junction boxes, often following floods or when looking for food and water. They are also attracted to electrical devices, such as air conditioners. Once inside, they may stay and nest if they can find a moisture source, such as a leaky pipe. When nesting inside, they also bring in soil, which can lead to its own set of problems, especially if the soil makes its way into your electrical devices.

PREVENTION

Structural

- Follow the ant trail and identify all points of entry into your home. If you don't have a clear ant trail, place small pieces of cardboard or wax paper

with an oily treat out at night. In the morning, there should be a thick ant trail leading to their doorway(s) into your home.

- To keep them out, lightly dust their possible entrances with talcum powder, medicated body powder or Comet® or smear petroleum jelly where you want to capture them and prevent their entry. Put down lines of cayenne and black pepper as repellants.
- Caulk and seal with aerosol foam insulation or screen all open voids, cracks, crevices (in houses, barns, etc.). Using toothpaste, petroleum jelly or duct tape as sealants will work temporarily; for permanent sealing, use silicone caulking.
- Make certain that all plumbing is in good repair, fix any leaky pipes or faucets that would serve as water sources for ant nests.

Cultural

- Clean up and remove food sources, especially cooking oils and grease, and fruits and nuts.
- Keep kitchen counters, stove tops and floors clean, put garbage in tightly sealed containers and empty it daily, and thoroughly rinse recyclables.
- Store oils, grains and pet food in glass jars with seals or gaskets and plastic containers with tight-fitting lids. Ants can climb up the threads of screw-top jars and get in if there is no gasket or liner.
- Place pet bowls in moats – a pie tin filled with plain soapy water and the food bowl placed in the middle can be effective in preventing ant access, but be sure your pet won't drink the soapy water.
- Outdoors, remove mulch, garbage, manure, debris, pieces of lumber, old equipment, weeds and grass; elevate bee hives; quickly remove dead animals and hay bales; and regularly mow and trim.

Biological

- Ants feed on "honeydew," a sweet substance produced by insects that feed on plant sap, such as aphids and scale. Control these insects and cut branches back from your house to prevent ant problems.

INSPECTION

You probably have imported fire ants if the following characteristics of the ants and their mounds are observed:

- Mounds of loose soil, resembling gopher diggings, are found above ground.
- Mounds are generally numerous and conspicuous.
- Worker ants are dark, small, highly variable in size, aggressive, and sting relentlessly.

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- Workers have the same body proportions from the tiniest to the largest. Head width never exceeds the abdomen width, even in the largest workers.

CONTROL

NON-TOXIC

Biological

- **Nematodes**, *Steinernema* spp., are commercially available for control of fire ants. They can be applied to individual mounds in a soil drench. A nematode formulation called Antidote® is commercially available for fire ant control.

- A promising biological control agent for fire ants is the **phorid fly**. Phorid flies are parasitoids that grow and pupate in the heads of their hosts, causing decapitation. They have a fairly narrow host range and can disrupt the foraging activity of an entire colony. Phorid flies are still being studied and are being released by many southern states at test sites to determine their effectiveness in fire ant control. Phorid flies in the genus *Pseudacteon* are among the most promising biological control agents for use against fire ants. *Pseudacteon tricuspis* Borgmeier is the one phorid fly currently available and approved for release.

- The treatment of individual mounds with the **fungus** *Bwauveria bassiana* has produced encouraging results, though it does not appear to be a practical field treatment.

- **Habitat modification** — fire ants prefer open, sunny pastures to forests and shaded places. For long-term control:
  - Plant trees in areas where extensive logging has taken place.
  - Mitigate the effects of development when forests are cut down.
  - Plant trees and shrubs in yards, and replace parts of the lawn with flower gardens and vegetative groundcover.

Mechanical Controls.

- **Bucketing** is one of the simplest ways of dealing with one or two problem colonies. Basically, the procedure is to rapidly dig the mound and a foot or so of soil under the mound and dump it into one or several large buckets. Sprinkling the bucket and shovel with baby powder or cornstarch before you start will keep the ants from climbing out of them. Remember to tuck your pants into your socks to keep the ants where you can see them. Dig up the soil at a time of day when most of the colony is in the mound. In the spring, the best time is usually mid- to late morning. In the summer, it might be

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early morning. Once the ants are in the bucket, you can either drown the ants or carry them to a place where they won't be a problem. If you choose to drown the ants, add a generous squirt of dish soap, water from a hose, and stir to mix the soap throughout the mud in the bucket. The soap breaks the surface tension and drowns the ants much more quickly. It usually takes overnight to kill the ants. In the heat of the summer, they will probably drown faster, but on cool days in the spring, it may take longer. It is best not to fill the buckets more than three-quarters full of ants and dirt so there is room to add the water.

- **Leveling** mounds with a steel beam drag, when coordinated with the ant's vulnerability, can be effective for control of large infestations. Mounds leveled in mid-winter immediately before the temperature dropped below freezing reduced the number of mounds by 50% the next year.

- **Hot water** can be effective as an individual mound treatment. A Florida State University study obtained "excellent to complete" fire ant mortality in 8 of 14 mounds when 3 gallons of hot water was slowly poured on each mound, taking care to collapse as much of the mound structure as possible. If the mound was hard and crusted, this was first broken. The water drained rapidly into the deep tunnels. Portable boilers are available commercially for treatment of mounds over a large area.

  Apply on a sunny, but cool, day when the ants are close to the surface. Treat the sunny side of the mound early in the morning, as there is a high probability that the queen is in this area.

LEAST-TOXIC

- **Diatomaceous earth** (D.E., silicone dioxide) products are usually dumped on mounds or applied as contact insecticides to ant trails indoors. D.E. abrades the waxy layer from the insect exoskeleton, causing the insect to desiccate. It is only effective in dry weather. Be sure to choose D.E that is not mixed with pyrethrins. **When using desiccating or boric acid dust, always wear a dust mask and goggles. Do not use diatomaceous earth if you have lung problems, as it can cause respiratory irritation if inhaled.**

- **Boric acid** bait can be used on individual mounds or broadcast over a large area where infestation is extensive. Do not apply baits if ants are not actively foraging.
  - You can broadcast freshly processed corn cob grits coated with soybean oil with 1% borax as a homemade bait in the spring and the fall, especially when no mounds are visible. If you bait in summer, bait in the late afternoon or at night. Use about 1 - 2 oz. per 1,000 square feet. The ants

will find the grits and extract the toxic oil for food. Pre-bait with potato chips to see where to place the baits.

If you have a mound, bait either around the mound up to 3 feet away, or in a bait container rather than broadcast the baits. Sprinkle potato chips around the mound and watch for ant activity to figure out where to place the baits. Do not put bait on top of the mound, unless you open it up first and wait 8 minutes.

- 10% sugar and 1% boric acid or borax liquid baits may eventually work but the control may take 3 - 4 months to obtain control.
- Try using a sweet bait (10%) with soybean oil (87%) and boric (3%) soaked into corncob grits or pieces of sponge.
- Try sliced raw fish soaked in a 5% - 10% boric acid bath for 10 minutes.

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APHID MANAGEMENT

IDENTIFICATION

Aphids belong to the homopteran family of insects. They will infest almost anything that grows in the garden and are prolific reproducers. They can range in size from 1/50- to 1/8-inch in length and can be light yellow to green to black, or reddish brown to grey. They have sucking mouth parts and distinguishing cornicles – tubes extending backward from the abdomen – from which they secrete honeydew, a sticky, sweet substance that is the waste product from their inability to totally process the sugars they consume from plants.

Aphids pierce holes in plant parts and suck sap from the host plant. They have two types of saliva, one that hardens the plant tissues and allows their mouths to more easily manipulate in the plant, and saliva that causes the plant cell walls and starches to break down for easier extraction from the plant. Some are winged and some will produce winged adults when conditions are unfavorable and survival depends on moving to a new location.

Aphids over-winter as shiny black eggs in the crevices of bud scales and bark and in other protected areas on the plant, and, after hatching in early spring, give birth to live nymphs that can give birth within a week. Females can produce a generation, which will produce further generations without mating, as females will produce females unless fertilization from a male takes place. Males mate with females at the end of the season, and the females lay eggs for the following year.

HABITAT

Aphids are always present in the environment. A small number of aphids on a plant generally will not cause a great deal of harm, but as numbers increase, damage becomes more serious and apparent. Aphid damage usually presents itself as leaf distortion or curl, bud distortion and fruit malformation or dwarfing as a result of early season damage. Aphids' honeydew attracts sooty mold, a fungus that can reduce photosynthesis. Aphids are also disease vectors, transmitting diseases among plants.

Populations are fairly stationary, but aphids can migrate to better feeding grounds if food supplies run low. Ants feeding on the honeydew will also physically move aphids to health plants to protect them from predators.

PREVENTION

Cultural

- Avoid over-fertilizing you garden, as aphids like to feed on nitrogen-rich hosts.
- Maintain good watering habits, as water-stressed plants will attract more aphids.
- Place reflective mulch, such as household aluminum foil, shiny side up, to confuse aphids and prevent them from landing on plants.
- Use floating row covers or cover crops with lightweight, transparent material to deter aphid (and other harmful insect) infestation.
- Because ants often kill or disturb natural enemies of aphids, ant control is an integral part of aphid management.
- Do not have aphid-attracting plants where aphids or their honeydew will do harm.

Biological

- Grow plants that attract and foster natural predators or repel aphids, such as yarrow, wild buckwheat, white sweet clover, sweet fennel, sweet alyssum, spearmint, Queen's Anne's lace, hairy vetch, flowering buckwheat, crimson clover, cowpeas common knotweed, caraway, marigolds, catnip or tansy.

INSPECTION

- Visually inspect plants for signs of an aphid infestation. Look especially at undersides of leaves and new buds or tip growth and watch for cast skins on leaves, yellow spots on upper leaf surfaces, curling of leaves and distortion of new growth. Choose plants randomly throughout the garden. For plants with fine foliage on which aphids may be difficult to detect, hold the plant over a white sheet of paper and gently tap to dislodge any aphids.
- Look for honeydew – a sticky shine or dark dust spots on the upper surfaces of the lower leaves of plants.

CONTROL

NON-TOXIC

- Remove the insects from the host plant by **spraying** the tops and bottoms of leaves with a strong stream of water. Spay either in early morning or late evening to avoid burning leaves.

- Use **sticky traps** to capture aphids – yellow traps seem to be most inviting. Once aphids are stuck to the traps, dunk it in soapy water to kill the aphids

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and dispose of the trap. Tanglefoot™ coated paper is effective for catching aphids, but must be placed where people and pets won't brush up against it.

- Encourage **natural predators and parasites,** such as green lacewings, lady bird beetles, syrphid flies and braconid wasps.
    - Reduce the number of aphids before initially introducing beneficial insects by pruning or applying insecticidal soap or horticultural oil.
    - Begin monitoring weekly before releases are made and get a rough count of the size of the pest population. Note how many insects are on how many leaves in what part of the greenhouse or garden, or how many leaves are infested in a sample of five to ten leaves within a group of plants. Keep a written record of your findings so you can determine the success of your releases and identify hot spots that may require further attention.
    - Initially release large numbers of beneficials; subsequent releases can be smaller.
    - Continue monitoring weekly or even more often to see whether the pest population is being suppressed and whether the beneficials are present.
    - Plan to make periodic releases during the year, the frequency of which should be based upon what was learned from monitoring. One release per year is rarely enough, but one per month may be excessive.
    - Keep records with the date, plant, pest, number of pests detected, beneficial released, number of beneficials released, and notes about the damage level or treatments used.

- The fungus *Beauveria bassiana* provides good control of aphids. It works by attaching to the outside of the insect, then penetrating into the body and killing it. It is available commercially as Naturalik-O™ or BotaniGard™.

LEAST-TOXIC

- Neem oil products, such as Bio-Neem™, Neemix™, or Rose Defense™ disrupt the hormonal balance of aphids, so they die before they molt into the next life cycle. It also suppresses the aphids' desire to feed, repels other insects, and acts as both a repellant and fungicide. To avoid harming beneficial insects, apply the products during early morning or late afternoon, when honeybees will not be active.

- Insecticidal soaps, such as Safer™ and M-Pede™ can be used for control of aphids. These products allow harder-bodied predator insects to survive and

naturally control aphids as well. These products can damage plants if used too often must be sprayed directly on the aphids in order to be effective.

- Horticultural oils (vegetable based), suffocate aphids when used in the winter and summer after leaves appear on the host plant.

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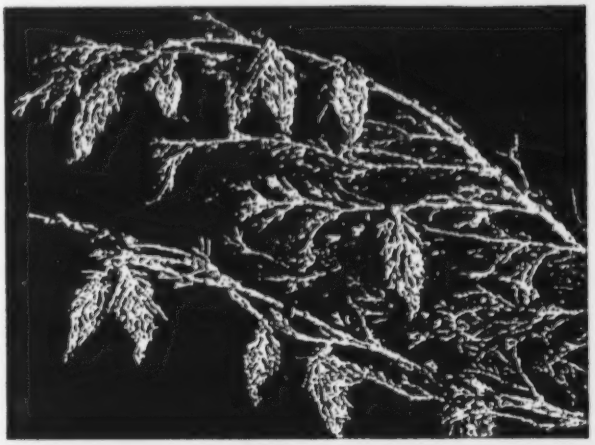
BAGWORM MANAGEMENT

IDENTIFICATION



Bagworms are the larval stage of moths. Only the male moth is capable of flight – the female is grub-like and remains inside the bag until just before she dies. They attach their bags to and feed on ornamental plants such as deciduous trees and evergreens, but are especially damaging to juniper, aborvitae, spruce, pine and cedar. They cause defoliation and eventual death of plants.

Bagworms look like green or brown bags about ½ to 3 inches long and hang from branches like ornaments. They are often mistaken for pinecones or other plant structures. They pass their winter as eggs inside the bag that contained the previous year's female. In mid to late May, the eggs hatch and the tiny larvae crawl out from the end of the bag in search of food. The larvae use bits of silk and plant material to construct a small bag around their hind part, enlarging the bag as they go in order to withdraw into it when disturbed. Older larvae strup evergreens of their needles and consume whole leaves of susceptible deciduous species, leaving only the larger veins. The bag is speckled with bits of whatever vegetation on which they are feeding.

The bags reach their maximum size in by early fall, at which time the larvae permanently suspend their bags from twigs and transform into pupa (the resting stage before becoming an adult). Adults emerge from the pupal stage in early fall.

Males are black, furry, clear-winged moths with about a 1-inch wingspan. They are active fliers and fly in search of females, which remain inside their bag. Females produce a powerful pheromone to attract males. They are creamy white and do not have legs or wings. The male flies to the female's bag and mates with the female. After she has laid several hundred eggs inside her pupal case within the bag, she drops from the bag and dies.

In temperate climates, the larvae hatch and begin feeding in late spring to early summer. Very young larvae can spin strands of silk and be carried fairly long distances by wind; larger may move short distances by crawling.

HABITAT

The most common species in the East usually attaches to junipers, pine hemlock, cedar, black locust, maple, sycamore, elm, buckeye, box elder and willow trees. In the Southern California region, bagworms are found mainly on ash, pear, sycamore, willow and locust trees. In Florida and other gulf coast states, look for bagworms on citrus and other subtropical plants.

PREVENTION

Cultural

- Monitor all plants that have been infected with bagworms in the past. Begin searching for bags in the winter, as some will contain eggs that will hatch in the spring. Destroy any that you find.

INSPECTION

- In May and early June, closely monitor all plants at least every other week.

CONTROL

NON-TOXIC

- When there are only a few bagworms, **handpick and crush** them.
- **Pheromone traps** lure and trap male bagworms, disrupting mating behavior.

LEAST-TOXIC

- If there are too many bagworms to handpick, consider using ***Bacillus thuringiensis*** **(Bt)**, a low-toxic microbial insecticide. This can be found at most hardware and garden stores. Bt is most effective against young larvae. Make sure to apply to small bags. Apply Bt only to plants infected with bagworms since Bt is toxic to other species of caterpillars as well.

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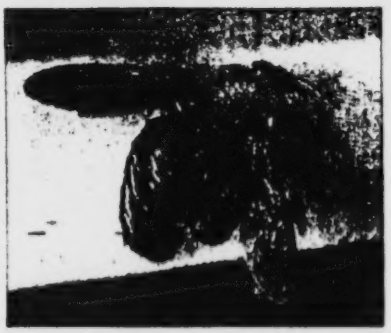
CARPENTER BEE MANAGEMENT



IDENTIFICATION

Carpenter bees should be protected whenever possible; they valuable pollinators and do not pose a threat to humans. They tunnel very slowly and their damage is very easily curbed.

Carpenter bees are most often confused with bumblebees. They are large, about 1 inch (25 mm) long and have a noticeably hairy thorax and legs, but a hairless abdomen. The abdomen is metallic or iridescent, and may reflect blue, blue-black, bronze, purple, green or buff, depending upon the species.

They fly and hover with little regard to human activity. Males cannot sting and pose no threat to humans, though their interactions are noisy and may seem threatening as they defend and challenge each other over their territories. Females concentrate on provisioning their nests and are most often seen entering and emerging from large entrance holes in wood or in flowers searching for pollen. They can sting, but won't, although they may bite if handled roughly.

As young adults, carpenter bees overwinter in wood, mate from April to June and then begin preparations for the next generation. The female may clean out a previously used gallery, lengthen an existing gallery, or bore a new tunnel or chew a new gallery from an entrance shared with or started by other bees.

HABITAT

Carpenter bees have distinct preferences for certain species of softwoods, and do not attack wood that is soft due to decay or tunnel in wood with bark still on it. Their favorites include southern yellow pine, white pine, California redwood, cedar, Douglas fir, and cypress. They chew with their mouthparts into structures, most frequently attacking roof trim and siding, exterior columns, steps, decks, and porch beams and railings. Their entrance is usually against the grain, except where it starts on the end of a board. Approximately 1 inch into the wood, the tunnel turns abruptly at a right angle, and, in newly excavated areas, travels with the grain from 4-6 inches. Several bees working together over a period of time can form a system of galleries extending as far as 6-9 feet into the timber.

INSPECTION

Signs of carpenter bees, other than visual detection, may include ½ inch round holes in wood siding, outdoor trim or other wood areas; sawdust-like debris below areas being tunneled; and woodpecker damage on the house.

PREVENTION

Structural

- Build exposed wood structures from types of wood not preferred by carpenter bees.
- Keep exposed wood in vulnerable areas covered with paint or varnish, or metal or fiberglass materials.

Cultural

- Fill depressions in wood, which will attract female carpenter bees, before painting.
- Repaint as often as necessary to keep up with weathering, paying particular attention to undersides of siding and trim.

CONTROL

NON-TOXIC

- After the bees have emerged, plug holes in wood with steel wool and staple on metal screen. Soft material such as wood putty or caulk will not prevent bee re-entry.

- Replace damaged wood with painted wood or materials not attractive to bees. The best time to physically renovate a structure is in the spring after the bees have left their nest.

- Almond oil and almond essence placed around the nest will temporarily repel carpenter bees until physical alterations can be made.

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CHIGGER MANAGEMENT

IDENTIFICATION

Chiggers are bright red mites that are parasitic to humans and other animals during their larval stage. At this time, they are about 1/150-inch in diameter and yellow, orange or light red in color. Adults are about 1/32-inch in diameter and covered with dense red hairs.

Their life cycle consists of an egg, sex-legged larva, and eight-legged nymph and adult. Eggs are laid on soil and hatch in about a week. Larvae seek out a host, feed on skin tissue fluids by inserting digestive juices into skin cells and ingesting the cell contents (they do not burrow under the skin), and then drop off and molt to a nymph and eventually into an adult. Egg to adult development takes about 50 to 70 days.

Peak chigger activity occurs from late spring to early fall.

HABITAT

Chiggers need high humidity to keep from drying out and dying. They commonly inhabit thickly vegetated and damp, shady areas such as in tall grass, along forest edges, and in wild blackberry patches. They can also live on lawns and golf courses.

Chiggers wait on the ground or on blades of grass and very quickly transfer to a host as it brushes by them. They are attracted to their host by carbon dioxide. They can wander about the host for hours before settling down to feed, usually on humans in areas where clothing is tight: the waist, crotch, armpits, backs of knees and ankles.

About three to 24 hours after the initial feeding by a chigger, a characteristic red, intense itching welt appears on the skin.

PREVENTION

Cultural

- When entering an area that may be inhabited with chiggers, wear herbal insect repellent. Any that are effective for mosquitoes will be effective for chiggers. Apply repellent to shoes, socks, lower pant legs, waistband, and sleeves.

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- Close off all openings in clothing when entering a chigger-infested area. Wear tightly woven socks, tuck socks into pants, wear rubber bands on sleeves around the wrists, and wear zippered clothing rather than buttons.
- After being in a susceptible area, shower with warm soapy water, and scrub possibly infested skin. If you can't shower right away, rub your skin down with a towel.
- Wash all clothing and blankets in water 125 degrees or above.
- To control chiggers on your lawn, keep your grass cut low and prune vegetation.
- Decreasing overall moisture will make the area less attractive to chiggers.
- Eliminate unnecessary shade and mulch that may harbor moisture.
- Continue these practices year after year as chiggers burrow into soil during the winter months and may re-infest an area in the spring.

INSPECTION

To determine whether or not an area is infested, set a three by five black piece of cardboard perpendicular to the ground. If chiggers are present, they will move up the cardboard and congregate along the top edge. They'll look like little yellow or pink dots moving about.

CONTROL

NON-TOXIC

- If you do become infested, **scrub away the chiggers**. Afterwards, carefully examine skin with a magnifying lens to make sure all chiggers have been removed.

LEAST-TOXIC

- If you feel it is absolutely necessary to use a chemical, the safest to use is **sulfur**. An effective mixture is 6% precipitated sulfur in Vaseline™ or other petrolatum base. You will most likely need a prescription to obtain this from a pharmacist. Two drugs are available: Mitigal™, which contains 25% organically combined sulfur, however this is liable to produce sulfur dermatitis; and Tetmosol™, which is used on children but is slow in action. You can make your own mixture. Purchase precipitated sulfur from a plant nursery, or technical-grade sulfur from a chemical supply house. Combine with a petrolatum, Eucerin™, Aquaquphor™ or a vanishing cream.

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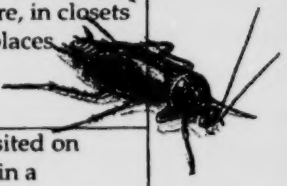
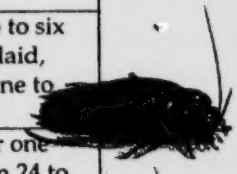
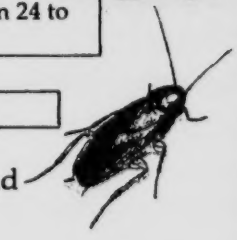
COCKROACH MANAGEMENT

IDENTIFICATION

Roach Species	Length	Color and Markings	Reproductive Characteristics
German	9/16 inch	Light brown with two dark stripes on the pronotum (section of the thorax behind the head)	Female carries egg case until 12 days before hatching, then drops it anywhere
Brownbanded	9/16 inch	Tan-golden with faint V-shaped lighter bands on wings	Egg case glued to ceilings, behind furniture, in closets or other dark places
Oriental	1-1/4 inch	Dark, red-brown-black throughout	Egg case deposited on debris or food in a sheltered place
American	1-3/4 inch	Reddish-brown throughout, with a pale band on the edge of the pronotum; Very large roach	Egg case carried up to six days; brown when laid, but turns black in one to two days
Smokybrown	1-1/2 inch	Pronotum a solid dark brown to black; Very large roach	Egg case carried for one day, will hatch from 24 to 70 days later







HABITAT

The key to long-term cockroach control is the elimination of food, water and harborage sources needed to survive.

Roaches evolved as scavengers of dead plant material and prefer carbohydrates to protein and fat as a result. They will, however, eat almost anything when hungry, such as starch-based paints, wallpaper paste, envelope glue and bar soaps, which all contain carbohydrates. Infestations often occur when roach egg cases are accidentally introduced in shipped materials, groceries, beer and soft-drink cases and used appliances, rugs and furniture.

Roaches have amazing migratory abilities. They can travel up elevator shafts and drains, through heating and air vents, tiny cracks and crevices in walls and above false ceilings. They commonly radiate out from areas that provide a steady food source, such as kitchens, pantries, restaurants, cafeterias, and garbage collection or disposal areas. When the weather is warm enough, they can migrate between structures outdoors along the outsides of buildings and from dumpsters to nearby living units.

The Australian roach is more vegetarian than other species, and may be found in greenhouses. The American roach enjoys moisture and life on the seas -- it is common on ships, as well as in basements and sewers. The smokybrown roach also can be found in sewers, but primarily lives outdoors. Oriental roaches are also moisture lovers, while the brownbanded roaches prefer warm, dry environments, such as closet shelves and the upper stories of houses.

German roaches have the widest distribution of all domestic roaches and are often found in dead leaves and garbage piles, but also readily invade cartons, sacks and containers, and will enter empty or open bottles. They invade the indoors from outdoor habitats in the summer only, and are usually found in basements and of first floors, having a preference for the warm area around furnaces and heating ducts. This is the most common roach to be seen in food preparation areas in restaurants, cafeterias and kitchens – environments where the combination of food, moisture and warm temperatures mimic that of their native East Africa.

This roach prefers squeezing into small cracks where their backs and undersides make contact with other surfaces. They are often found backed into cracks with their antennae and heads sticking out, picking up chemical signals from the air, which their behavior is more dependent upon than vision or sound. They become more active 20 minutes to 2 hours before dark, and increase their activity to a peak ending before daybreak. Only when populations are very high will they be active during daylight.

PREVENTION

Structural

- Caulk, weather-strip, and repair any holes larger than 1/16" around water pipes, baseboards, electrical fixtures, outlets and switches, doors, and windows.
- Put screens over windows, vents, floor and sink drains, and ducts, which can be cockroach highways and hideaways.
- Stack woodpiles away from the building, and keep the outside of the building clean of trash and leaves.
- Fix leaky faucets and drains.
- Insulate pipes to prevent condensation.

Cultural

- Eliminate newspapers, magazines, paper bags, etc...
- Inspect all bags, baskets or boxes of food brought into the building.
- Store food in tightly sealed containers or in the refrigerator.
- Do not leave food, crumbs, or trash uncovered, dirty dishes sitting out, or pet food out overnight.

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- Clean all spills immediately, wipe all counters and tables after use, and be sure to keep the stove grease free, as well as food free.
- Use trash cans with a tight-fitting lids and avoid placing them under sinks.
- Rinse food and drink containers before throwing them away or recycling them, and empty trash and recycling frequently.
- Avoid soaking dishes overnight, place sponges and dishrags in an airtight container, and avoid overwatering plants.

INSPECTION

Once a month, place two sticky traps per room where roaches would be traveling (where floor meets wall or countertop, inside cupboards, under sink, behind appliances) and leave them for 24 hours.

CONTROL

LEAST-TOXIC

- If you discover a cockroach problem, boric acid is the most effective direct control method. Apply boric acid (a 99% formulation) to cracks and crevices where roaches hide – inside and behind cabinets and appliances, wall cavities, under the sink, etc... Roaches are killed in three to ten days. **Use boric acid with care, and keep it away from children and pets.**

- Desiccating dust, such as diatomaceous earth or silica gel can be blown into voids through small holes drilled into the walls. Be sure to choose a dust that is **not** mixed with a pyrethrin. Dusts placed in wall voids or cracks and sealed can be effective for many years if they are kept dry. **When using desiccating or boric acid dust, always wear a dust mask and goggles and cover any electronic equipment that could suffer dust damage. Do not use diatomaceous earth if you have lung problems, as it can cause respiratory irritation if inhaled.**

ELM LEAF BEETLE MANAGEMENT

IDENTIFICATION

Elm leaf beetles are one of the most important insects damaging urban forests in the United States. These beetles feed on tree leaves, mainly causing aesthetic damage, but the stress to the tree may cause susceptibility to disease.

Adult beetles are about ¼-inch long and olive green with black stripes down the center and on either side of the back. Females lay their yellowish to gray eggs in double rows of about five to 25 on the underside of leaves. Larvae are black when newly hatched, but after feeding they become dull yellow or green with rows of tiny, dark tubercles (projections). Larvae develop through three stages or instars. Third instar larvae have dense rows of dark tubercles that resemble two black stripes down their sides, making them easy to distinguish from first- and second-instar larvae. Mature third instars are up to 1/3-inch long. Pupae are orange to bright yellow.

Adult beetles overwinter in dry protected areas such as bark crevices, litter, woodpiles, garages or attics. They do not bite or damage fabric or furniture. In the spring, the adults fly to nearby elm trees and begin to feed. Population levels are low at this point in the season. Eggs are laid on the leaves – yellow at first and then gray right before hatching. When the larvae hatch, they feed on the leaves for several weeks. Mature larvae then descend the tree trunk to pupate. As adults (after about 18 days) they fly back to the leaves of the tree and continue feeding.

The cycle repeats itself (two times in warmer climates). Adults emerging in the fall find a protected home for the winter.

Elm leaf beetles are serious defoliators of elms. Larvae skeletonize the leaf surface, and adults chew entirely through the leaf, often in a shothole pattern. The defoliation eliminates summer shade, reduces the aesthetic value of trees, and causes leaf drop. Repeated, extensive defoliation causes trees to decline.

HABITAT

Elm leaf beetles attack all species of elm, but prefer English and American Elms.

PREVENTION

Cultural

- Take good cultural care of trees, providing proper irrigation.
- Protect trees from injury to trunks and roots.
- Check elms for dead or dying branches and properly prune these out during the late fall and winter. Avoid pruning during the spring and summer – the European elm bark beetle, which vectors Dutch elm disease, is attracted to feed around fresh pruning wounds in the spring and summer.
- Prevent elm leaf beetles from entering your home by using barrier treatments.

Biological

- Conserve and protect these natural predators by avoiding foliar applications of broad-spectrum insecticides and using less-toxic materials.
- Do not plant English or Scotch elms, which are especially susceptible to both elm leaf beetles and Dutch elm disease. Consider replacing them in areas where they are already growing.

INSPECTION

- Evaluate beetle populations during the spring by inspecting foliage weekly for beetles starting in April. Watch for the appearance of yellowish eggs. If you do not see any eggs, you probably do not have a problem. If there are a large enough number of larvae, take control measures.

- Establish treatment thresholds. Healthy elm trees can tolerate substantial damage to leaves. Total defoliation may have little long-term effect on healthy elms, especially if leaf damage occurs late in the season. Suggested treatment thresholds are 40% defoliation (portion of leaf area chewed or leaves dropped prematurely) or 20% defoliation if damage is less tolerable.

CONTROL

Management of elm leaf beetles must incorporate good cultural practices, conservation of natural enemies, regular monitoring, use of least-toxic insecticides and, as an absolute last resort, bark banding with insecticides or systemic insecticides. Beetle populations will vary from year-to-year, and most trees do not require treatment every year. Management efforts should encompass all elms in the area, as adult beetles fly from tree to tree.

NON-TOXIC

- Vacuum up any beetles that enter the home.

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- **The black tachinid fly** is an important parasite that preys upon the elm leaf beetle. It emerges from mature beetle larvae. It's black to reddish, cylinder- or teardrop-shaped pupae occur during spring and summer at the base of trees among the yellowish beetle pupae. It overwinters in adult beetles, emerging as adults in spring.

- Two tiny wasps also parasitize the elm leaf beetle – *Oomyzus brevistigma* and *Oomyzus gallerucae*. *Oomyzus brevistigma* parasitizes mature larvae and pupae, leaving one or more small, round holes in beetle pupae where it has emerged. *Oomyzus gallerucae* is an egg parasite, leaving round holes when it emerges from beetle eggs, which remain golden.

LEAST TOXIC

- Foliar applications of ***Bacillus thuringiensis v. tenebrionis*** **(Btt),** a microbial pesticide that specifically controls the larvae of the elm leaf beetle, is an effective, least-toxic method of control. It affects the larvae of the beetles, infecting them with bacteria and killing them. It is commercially available as M-One™ and available from Mycogen in San Diego. The trick is to watch for the first generation of larvae to appear and treat them after all the egg masses have hatched but before the larvae have started down the tree.

- **Bark Banding** is an inexpensive technique that involves spraying a small are of the tree trunk with an insecticide. Use a hand-pump sprayer or hydraulic sprayer at low pressure to spray a band of bark several feet wide around the first main branch crotch. Larvae are killed by the insecticide when crawling down to pupate at the tree base after feeding in the canopy. Determine the best time to spray the trunk by inspecting the foliage and spraying when mature larvae are first observed. To determine if the band is effective, regularly inspect around the base of trees throughout the season. If many beetles have changed from greenish prepupae to bright yellowish pupae, another application may be warranted. Permethrin, a toxic pesticide, is recommended for bark banding, but should only be used as an absolute last resort.

FLEA CONTROL

IDENTIFICATION

The most common species of flea to become a problem in the home are the cat flea, dog flea and human flea, with the cat flea being the most commonly encountered. Cat and dog fleas enjoy both cats and dogs, as well as chickens, rats, opossums, raccoons and possums. The human flea is now found mostly on pigs. They all readily bite people.

Fleas can become a problem regardless of whether or not there are pets in the building. They can be brought in on the clothing of staff, students or visitors, or become problems from urban wildlife lining in unused parts of the buildings, such as rats, feral cats, raccoons, opossums, chipmunks, squirrels, or birds.

Flea bites cause irritation and serious allergies in animals and humans. Cat fleas, less commonly, can carry and transmit organisms causing the bubonic plague, murine typhus and the double-pored dog tapeworm, which can live in dogs, cats and humans.

Adult fleas are about 1/16 to 1/8-inch long, dark reddish-brown, wingless, hard-bodied (difficult to crush between fingers), have three pairs of legs, with enlarged hind legs for jumping, and are flattened side to side allowing easy movement between the hair, fur or feathers of the host. Fleas are excellent jumpers, leaping vertically up to seven inches and horizontally thirteen inches. (An equivalent hop for a human would be 250 feet vertically and 450 feet horizontally.) They have piercing-sucking mouthparts, spines on the body projecting backward and a row of spines on the face. Eggs are smooth, oval and white. Larvae are 1/4-inch long, slender, straw-colored, brown headed, wormlike, bristly-haired creatures. They are legless, have chewing mouthparts, are active, and avoid light.

HABITAT

The larvae of the cat and dog flea prefer an environment of dust and organic debris, and are very common in yards and under houses. They are also found in the cracks and crevices of pet beds, in cracks and crevices of structures, in carpets, and on pets. Adult fleas prefer warm, fuzzy hosts where they can have a blood meal at will, but will survive in any of the areas mentioned in between meals.

PREVENTION

Structural

- Seal up cracks and crevices both in and outside of buildings that may harbor flea larvae.
- Block off all entrance points in buildings that may invite wildlife inhabitation. Be sure all wildlife is out of the area before sealing.

Cultural

- Vacuum daily with a strong vacuum cleaner, changing the collection bag often.
- Groom the pet daily with a flea comb. After each stroke, check for fleas caught in the comb, picking off and dumping any in soapy water.
- Bathe the pet frequently with soap and water.
- Restrict the pet to a single bed, washing the bedding frequently to kill larvae and adults.

INSPECTION

Detection can be as simple as seeing fleas or noticing bites around the ankles of people in the building. Flea dirt, the adult flea feces that dries and falls off the host to serve as food for larvae, may also be visible.

Monitor in and around the cages of pets kept in classrooms, the pets themselves for signs of fleas, and places where animals may find shelter, such as basements, crawl spaces, attics, eaves, roof top structures, and secluded shrubbery near buildings.

Traps can also be used to detect flea populations.

- **Flea Sock Traps** are homemade, knee-high, white flannel booties that fit over the shoes and lower pant legs, as well as make a fashion statement. When walking through flea-infested areas, fleas will jump onto the flannel and become tangled in the nap. You can easily see and count them to determine the degree of infestation. In a pinch, long, white athletic socks worn over shoes and pant legs will work, as will wide strips of sticky-backed paper wrapped sticky-side-out around the lower legs.

- **Light Traps** are compact traps composed of a small electric light and a sheet of sticky paper. Adult cat fleas may be attracted to the warmth and light of the trap, hop over, and get stuck on the paper. Fleas are more sensitive to green light, and are more attracted to light traps if the light is turned off for 10 seconds every 5 or 10 minutes.

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The light trap should be checked once a week. If no fleas are caught by the second week, move the trap to another location or remove it. If only a few fleas are caught, the infestation is very small and can probably be controlled by the traps alone, and the traps should be left in place until no additional fleas have been caught for a week. If 20 or more fleas are caught in a week, there is probably a more serious infestation, and it is time to find the source.

If there are persistent flea problems buildings where there are no pets, it may be an indicator of the presence of rodents or other wildlife. Have the fleas identified, which can help determine the host animal and where to search to find the animal and its nest.

CONTROL

NON-TOXIC

- **Comb classroom pets regularly** with a flea comb, dropping any fleas and eggs in soapy water.
- **Remove wild animals** nesting in the building.
- **Vacuum** on a regular basis throughout the year, picking up adult and egg-stage fleas. Vacuum up a tablespoon of cornstarch to ensure the fleas' demise, and dispose of the bag immediately. Be sure to clean cracks and crevices, and permanently seal these openings. Vacuum vibrations will also stimulate new adult fleas to emerge from their pupal sacs, to be captured in the next vacuuming. Vacuum daily, if the area is badly infested, until the infestation is controlled. You will not capture the flea larvae in carpeting, because they are coiled around the fibers, but you will remove the dried blood on which they feed.
- **Steam cleaning** may be needed as a supplement to vacuuming in cases of severe infestation. It kills adult and larval fleas, as well as some eggs. The warmth and humidity of the steam may also stimulate remaining flea eggs to hatch a day or two after the cleaning, so some fleas may reappear. The few fleas that hatch after the steam cleaning should be the last of the flea population, and can be caught with a vacuum.
- **Wash removable floor coverings** located in areas where there are known infestations, as well as any bedding for classroom pets.
- The same **light traps** mentioned above are effective for flea control, using either sticky paper or a small tub of soapy water to catch attracted fleas.

- **Heat treatment** is also effective to control cat flea infestations. Cat flea larvae die after exposure to 103°F for one hour. The heating process uses a common heating unit modified to include special blowers and flexible ducts.

- **Drying or saturating** infested areas, such as outdoor areas temporarily harboring flea larvae, will kill eggs and larvae.

- **Nematodes** applied to the lawn as a spray enter the fleas' bodies, feeding on tissue and releasing harmful bacteria. They do not affect people, pets or plants, and occur naturally in soil, so they will not adversely affect beneficial soil organisms. Use the number of nematodes recommended by the manufacturer; treat areas where you have found evidence of flea infestation, animals sleeping, or regular travel routes for animals; and water the area before and after the application.

LEAST-TOXIC

- **Diatomaceous earth or silica aerogel** is effective flea control when applied in a light dusting to upholstered furniture that is suspected of harboring fleas (especially in cracks and crevices), rugs or pet bedding; applied to infested carpets, left for a couple of days and then vacuumed up; and sprinkled in crawl spaces, wall voids, attics and other spaces where animals may be nesting or sleeping. Do not use in moist environments. Choose a desiccating dust that it is **not combined with a pyrethrin**. Diatomaceous earth must be garden/food grade, as swimming pool grade is associated with lung disease. Desiccating dusts abrade the outer shell of the termites, causing them to dry out and die. **Avoid breathing in desiccating dusts, as they can cause lung irritation, and always wear a mask and goggles when applying.**

- **D-limonene and linalool** are citrus extracts that have proven effective for flea control. Products containing d-limonene kill larval and adult fleas, while those containing both ingredients kill eggs as well. There are EPA-registered shampoos containing these ingredients, but read the label carefully, as some are too strong for cats or young animals. **Limonene is listed as a volatile organic compound (VOC) by the EPA, which can be associated with irritation, odors and other health and comfort concerns. Those with existing sensitivities should be extremely careful when using a product containing limonene, or consider using another alternative.**

- **Boric acid** worked into the nap of carpet can be used to control fleas. It works as a "stomach poison" for fleas and will remain viable for up to a year. Exercise caution when using products containing boric acid, and **do not use it in areas where children or pets will come in direct contact with the chemical.**

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FLY MANAGEMENT

IDENTIFICATION/HABITAT

There are over 85,000 known species of flies. See the chart below for some common fly types.

Fly Species	Description	Habits
Housefly	About ¼ inch long; Grey, four stripes on thorax	Enters houses
Vinegar fly	Less than ¼ inch long; Yellow-brown	Hovers over rotten fruit and vegetables
Drain fly	Less than ¼ inch long; Gnat-like wings held roof-like over body	Larvae develop in sewage and kitchens
False stable fly	About ¼ inch long; Similar to housefly; Red mark on back	Found in decomposing organic matter
Little housefly	Less than ¼ inch long; Dull grey, yellow on upper abdomen	Male circles in shady areas; Larvae feed on garbage and pet feces
Cluster fly	Larger than ¼ inch; Similar to housefly; Hairy abdomen, yellow hair on sides	Larvae parasitise earthworms; Adults enter houses, especially during warm winter spells and cluster around windows
Green bottle fly	About ¼ inch long; Green to bronze	Seen on dog feces; Particularly prevalent in urban areas; Produced mainly in household garbage

The common food source for all filth fly larvae and for common pest flies of homes, restaurants, and urban areas are human food wastes, including garbage and pet feces.

PREVENTION

Structural

- Screens are the best means of preventing the entry of flies into the building. Window screens must fit tightly, screen doors must be fitted with springs that close them firmly after opened; both must be well maintained and, if ripped, mended promptly.

Cultural

- Wash dirty dishes promptly; do not leave them soaking overnight.
- Do not leave "wet" pet food sitting out.
- Secure kitchen garbage, both indoors and out, in tightly wrapped plastic bags.

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- Use garbage cans with tight fitting lids and fasteners that prevent them from being opened by wind or wildlife.
- In hot weather especially, wash out garbage cans and dumpsters with hot soapy water after they have been emptied to kill any lingering larvae.
- Rinse any recyclables free of remaining food or liquid.
- Use compost bins with solid sides and close fitting lids. Regularly turn the compost so that the outsides of the pile are folded into the center, making sure all portions are subjected to the heat.
- Scoop and dispose of or bury pet feces.

INSPECTION

To find the source of flies and their breeding site, it is important to identify your pest fly.

- Indoors, adult flies found near windows can be captured by pressing an open jar against the window where the fly is resting, then sliding a piece of paper or cardboard over the end of the jar while holding it loosely against the window or sill.
- Outdoors, the best means of catching pest flies is with a trap. Nuisance flies have highly developed senses of smell and can be attracted to a trap containing the right odor – buttermilk, molasses and syrup, sweet-smelling fermenting foods and kitchen scraps, but not meat or manure.

CONTROL

NON-TOXIC

- **Fly swatters** are a quick and safe way to control fly invasions. Those with thin wire stems and natural fiber heads are superior to the less-flexible, plastic-head variety.

- **Flypaper**, though not aesthetically pleasing, is an effective control in garages and storage areas and are available at most hardware stores.

- **Traps** can be used to reduce adult fly populations and monitor the effectiveness of control programs. Flies are attracted to the bait in the saucer or plate at the bottom of the trap. Once flying in, they can't escape. A mixture of cornmeal and molasses ferments, attracting many varieties of flies, and flies cannot develop in the mixture, as they may be able to in other bait options, because it has no protein. Yeast, dissolved in water, can be added to the bait to speed up the fermenting process. It is essential to keep the bait moist for it to remain effective; commercial traps are available that

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continuously moisten the bait.

- **Ultraviolet light traps** are effective indoors in areas where food is cooked, but are non-selective in the insects that they kill, so should be used with caution.

LEAST-TOXIC

- **Boric acid** is an effective fly control treatment in manure and sewage. It sterilizes female and also kills adult flies. One pound of boric acid per 100 ft.^{2} of straw in stables is effective against house fly breeding, except in heavy rains. 1.2% borax in cattle manure was found to be ovicidal to fly eggs. It is also effective when mixed with baits for control of houseflies. **Always be cautious with boric acid and keep away from children and animals.**

GRUB MANAGEMENT

IDENTIFICATION

White grubs are the larval stage of several species of soil-inhabiting beetles that are similar in general appearance and habits. The larvae or grubs pass through three stages, are crescent-shaped, live in the soil, where they feed on the roots of many important ornamental and agricultural plants.

Southern masked chafers are yellow-brown in color and about ½-inch long and ¼-inch wide. They are stout bodied. The adults do not feed and are not a pest of foliage. This grub has a one-year life cycle and is referred to as the "annual" white grub. By late March, overwintering third instar grubs begin migrating upward near the soil surface to feed. They continue feeding on grass roots and organic matter until May, and then move back deeper into the soil to pupate. Adults emerge from the soil June through early August at about dusk. Swarms of males fly low over turf in search of females. Eggs are usually laid in the top two inches of soil, and developing grubs will reach the final instar late in the summer and in early fall. Most turf damage is done in September and early October when the grubs are full-sized and feeding vigorously. Feeding continues until temperatures drop and force the grubs to migrate five to 10 inches deep into the soil to hibernate.

Many species of May or June beetles are also turfgrass pests. Adults feed on and can be serious pests of shade trees and ornamental shrubs. Adults are from ½- to one-inch long, the body is light to dark brown, and the head is dark brown. It takes, depending on the species, from one to four years to complete one generation.

The most common May or June beetles have a three-year life cycle. In year one, overwintering adults begin to emerge from the soil to feed and mate in early May. Emergence continues through June, sometimes into July. The adults are nocturnal and often only seen when they are attracted to a porch or window late at night. During the day, adults can be found buried in the soil or sod. Females will lay, on average, about 50 eggs over a one- to three-week period. Eggs are deposited three to four inches in the soil. Newly hatched larvae (first instar) feed on the organic material found in the soil, and then on roots. By August, the grubs have developed into the second instar and will burrow deep into the soil to hibernate in late fall. Minor turf damage can occur late in the summer of the first year.

During year two, the overwintering second-instar grubs move back to the soil surface and resume feeding by late March or April. By June, they develop into third-instar larvae and feed actively on roots, causing the most turf damage. Most species feed four to six months during this time of their life cycle. In late September and October they migrate into the soil to hibernate.

Overwintering third-instar grubs become active and move toward the soil surface for a brief feeding period in late March of year three. Minor turf damage can occur early in the summer as the larvae complete their feeding before pupation in late July. By September they develop into adults. The young adults remain underground until they emerge to feed and mate the following spring and complete their life cycle.

Grubs cause gradual thinning and weakening of the stand of turfgrass. Damage may progress from thinning to small patches of dead grass to the sudden wilting of the grass even with adequate soil moisture. Undamaged roots cannot obtain enough moisture to keep the grass green, and patches of lawn turn brown. In some cases, grubs destroy the entire root system and the sod can be lifted up easily.

Their high numbers can also attract birds, such as starlings, grackles and crows, and mammals, such as moles, shrews, chipmunks, skunks, and raccoons, which can cause further damage as they tear at the turf in search of grubs for food.

HABITAT

White grubs require moist soil for their eggs to hatch. Young grubs are very susceptible to desiccation. Turf next to regularly watered ornamental plants is favored by adults as oviposition sites.

PREVENTION

Cultural

- The most vigorous lawn growth occurs in loose, loamy soil with plenty of microorganisms, insects, worms, and other organisms. These organisms play a critical role in transforming thatch and grass clippings into humus. Humus slowly releases nutrients and buffers grass roots from extremes of drought or other stresses. Soil organisms also can protect lawn roots from the attack of soil pathogens or insects. To improve poor soil and maintain healthy soil, insure that organic matter is routinely replenished by leaving grass clippings to decompose and fertilizing or topdressing with organic materials, such as sludge and composted manure.

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- Water properly. The length of time needed to adequately water lawns is determined by the time it takes to wet it to the depth of the root system. Most lawn grass roots extend four to six inches in the soil. Infrequent, deep irrigation is preferred since frequent, shallow watering promotes shallow rooting. Use a soil probe or pointed tool to determine when siol is wet four to six inches below the soil. In areas where turf can stand moisture stress, do not water as much in the hot summer months, particularly in July and August when adults are laying eggs and young grubs are present.
- Keep the turf at a proper pH.
- Reduce soil compaction by aerating the lawn two to four times per year, topdressing, and rotating mowing patterns.
- Mow high (two and a half to three inches) to encourage deep-rooted, strong grass. Keeping the soil shaded with a dense canopy of grass will also make weed seeds less likely to germinate. It may be necessary to mow weekly when grasses are growing vigorously, but when grasses are semi-dormant, 14 to 21 days may be more appropriate between mowing. The right interval between mowing allows grasses to recover from the previous cut and enter the second growth phase when new blades, called tillers, are produced from the growing points.

Biological

- Plant or overseed with naturally resistant turfgrass, such as some types of perennial ryegrasses, tall fescues and fine fescues, and Kentucky bluegrass. The best time to overseed is in early fall. Contact your local Cooperative Extension Service to find out what species are suitable for your area.

INSPECTION

Grub populations can be estimated by examining several areas of soil underneath the grass. Cut three sides of a one-foot square piece of sod in several areas of the lawn, and carefully pull it back the square, using the uncut edge as a hinge. Scrape the soil from the roots to expose the grubs and count them.

A lawn growing from fertile, well-aerated soil that has received a moderate amount of fertilizer or nutrients will be best able to withstand an infestation. If the soil is moist the grass will survive longer. If there is more than 10 Southern masked chafers or five May-June beetle grubs per square foot, treatment is recommended. It is not unusual to have more than one species of white grubs infesting the same lawn. Replace the sod squares back on the soil.

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CONTROL

NON-TOXIC

- **Parasites**--Releasing natural enemies or parasites of an exotic insect is a successfully proven method to reduce pest populations. Two parasites of the Japanese beetle have been brought to the United States from Asia. Researchers have successfully established these insects in areas inhabited by the Japanese beetle, and the parasites are now functioning as important biological control agents of the beetle.

  Tiphia vernalis, a parasite of the Japanese beetle grub, and *Istocheta aldrichi*, a parasite of the adult, have been shown to be important in regulating the population dynamics of the beetle in the Northeastern United States. These parasites are not yet commercially available; however, you can contact your local extension agent to see if they are established in your area. If they are, planting the appropriate food plants will attract these parasites and increase the rates of parasitization, and thus help control the Japanese beetle on your property.

  Tiphia vernalis--This small, parasitic wasp of Japanese beetle grubs resembles a large, black, winged ant. Its current distribution is believed to be throughout the Northeastern United States and south to North Carolina. After a brief period of feeding and mating during the spring, the female wasp digs into the soil, paralyzes a beetle grub by stinging, and then deposits an egg on the grub. When the egg hatches, the emerging wasp larva consumes the grub.

  Food sources: Adult wasps of this species feed almost exclusively on the honeydew of aphids associated with the leaves of maple, cherry, and elm trees and peonies. In North Carolina, the nectar of tulip poplars has been found to be an important food source for the adult wasps.

  Istocheta aldrichi--This solitary fly is an internal parasite of the adult Japanese beetle. The female flies are capable of depositing up to 100 eggs during a period of about 2 weeks. The eggs are usually laid on the thorax of the female beetles. Upon hatching, the maggot bores directly into the beetle's body cavity, killing the beetle. Because it does not take this fly long to kill the beetle, *I. aldrichi* can suppress Japanese beetle populations before beetles can reproduce.

  Food sources: *I. aldrichi* is commonly seen feeding on aphid nectar deposited on Japanese knotweed (*Polygonum cuspidatum*), a persistent perennial weed native to Japan.

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- Grubs near the surface can be killed **by spiked implements**. You can reduce populations by walking over well-irrigated turf with spiked sandals. Check the results of this by rolling back a square of turf and counting the number of grubs before and after the procedure. A lawn aerator may also be effective, but the plugs may be too far apart.

- **Parasitic nematodes** in the genera *Steinernema* and *Heterorhabtitis* are an effective biological control option for grubs. They are non-selective and parasitize over 250 different root zone pests. Nematodes enter the host through a body opening or side-wall tissue and release a bacterium that begins to destroy within 72 hours. They can survive in soil 60-90 days without finding a host. Nematodes can reproduce inside the insect – two nematodes in a ¾ -inch larvae can reproduce as many as 200,000 more nematodes in the next two to three weeks. *Heterorhabtitis* works in cool as well as warm soils, and inhabits the top 15 cm of soil. *Steinernema* work best in warm soils, but there are some strains becoming available that claim to be effective in cool soils. Nematode control may take time, as the nematodes have to seek out and kill the grubs.

  Soil moisture is very important when using nematodes, as they will die if they dry out. Spray them on irrigated turf and lightly water them in. Eliminate thatch if it is over a half-inch thick so that the nematodes will reach the soil. Be sure to follow the directions given for application and storage on the package.

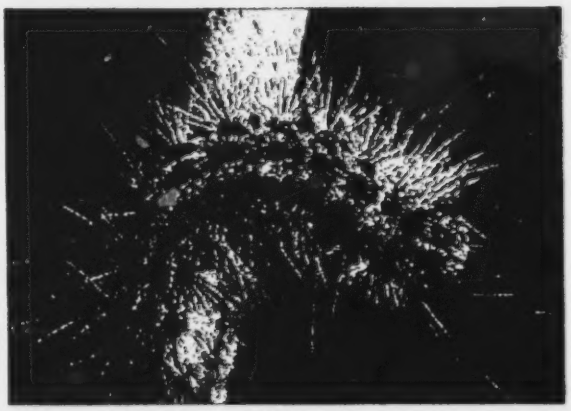
- **Milky spore disease** is a naturally occurring bacterium that affects grubs. When grubs are feeding, they ingest the bacteria. The bacteria begin to multiply inside the gut of the grub, killing it in about 14 days. When the grubs begin to decompose, billions of new bacteria are released into the soil. Warm climates can achieve complete control in two to three years, while colder climates may take three to five years. Once established in the lawn, milky spore can last 15 to 20 years.

LEAST TOXIC

- ***Bacillus thuringiensis* (Bt)**--Bt is a naturally occurring soil bacterium typically used as a microbial insecticide. The Bt strain registered for the Japanese beetle is for use on the grub stage only. Bt is a stomach poison and must be ingested to be effective. It is applied directly to the soil where grubs are present.

GYPSY MOTH MANAGEMENT

IDENTIFICATION



Gypsy moths have been a periodic problem in the U.S. since 1969, when it escaped from cultures maintained by a scientist trying to establish a "native" silk industry. It is identified as a destructive pest, causing individuals, and local and state governments to intervene.

Female gypsy moths deposit egg masses containing 75 to 1,000 eggs in June or July and then die. New masses are firm and buff colored, older masses are darkened. Hatched masses are spongy, and small, pin-sized holes indicate that parasites have emerged. Masses may be found anywhere – in the leaf litter beneath trees, at the tops of trees, on vehicles and outdoor furniture, in woodpiles, in rock walls, and beneath roof shingles. Most eggs are laid on the trees in protected refuges, such as bark flaps, crevices and holes.

Gypsy moths overwinter as diapausing eggs within the mass. Larvae hatch from overwintering eggs when the weather begins to warm in April or May. They may hatch over a three to five day period, or over two to three weeks, depending on the location of the mass and its exposure to sunlight. They may remain in the mass for several days if it is cold or raining. In favorable conditions, they climb trees, leaving a trail of silk behind them. They drop on silken threads from the tops of trees or branch ends. The threads are easily broken by slight gusts of wind, and both the long hairs of the larvae and the silk add buoyancy to the wind-blown insect. Several wind-blown dispersals may occur before larvae settle to feed.

First-stage larvae chew small holes within the leaf. When not eating, they rest on a mat of silk made on the undersides of leaves. Second- and third-stage larvae feed at the edges of leaves in tree tops, moving to the undersides of branches and twigs when not feeding. After molting to the fourth stage, large larvae feed during the night and descend the trees at dawn in search of shelter to avoid the intensity of the light. They prefer to hide under bark flaps or on trees, but will seek hiding places on the ground if necessary. At very high densities, the larvae feed continuously day and night, and defoliation can become severe at this stage. Mature caterpillars are one and one-half to two inches long. Larval stages last from four to ten days, depending on the temperature. Males molt through five stages, and females through six.

Pupae are formed in late June or early July, when larvae begin to attach themselves to the substrate, usually where they rested as late-stage larvae. Pupation lasts about two weeks.

Adult males are strong fliers. Females cannot fly, but release a strong sex attractant that lures the males. They mate, and the female deposits her eggs in a single mass – usually where she pupated.

In the initial years of an outbreak, the gypsy moth feeds mainly oaks, and, as its density increases, on many other species. A single complete defoliation rarely results in the death of a tree, but repeated severe defoliations can result in stress through depletion of carbohydrate reserves. Once weakened, trees are susceptible to attack by borers and fungus, and then may be further weakened by wounds, drought, winds, snow, frosts, diseases, parasites, and predators.

The best way to attack a gypsy moth problem is to attempt non-chemical pest management strategies first. There are inherent risks associated with all pesticides, and a number of steps that can be taken as alternatives to chemical insecticides.

HABITAT

The gypsy moth commonly occurs in the region north and east of Pennsylvania, including Michigan, Ohio, Delaware, Maryland, and some parts of Canada. There are small pockets or scattered, isolated infestations under quarantine elsewhere in the United States. It is native to the temperate regions of Europe, southern Asia and Africa, where it does less damage than in North America.

Gypsy moth caterpillars prefer to eat oak, birch, apple, willow, linden, hawthorn, and sweet gum trees. Older caterpillars may also attack crabapple, cherry, beech, hickory, walnut, hemlock, and pine trees. They avoid tulip poplar, sycamore, eastern red cedar, American holly, ash, black locust, dogwood, catalpa, butternut, black walnut, holly, and balsam fir trees.

PREVENTION

Cultural

- Trees should be maintained in a healthy and vigorous condition.
- Remove debris that may provide shelter gypsy moth larvae.

INSPECTION

Look for and destroy any egg masses in late summer, and again the following spring.

CONTROL

NON-TOXIC

- **Destroy egg masses** in the winter and spring before they hatch. Egg masses are light tan to pale yellow and are laid in June or July. They overwinter and hatch around April 1 the following spring. An egg mass can be as large as a 50-cent piece, is usually oval and flat, and has a felt-like texture. They are found in sheltered locations, such as under tree limbs, tree trunks, tree wounds, corners around windows and doors, house eaves, gutters, fences, and woodpiles. Egg masses should be destroyed whenever possible by scraping them into a container

- **Sticky barrier bands** keep caterpillars from climbing up the tree trunks. A barrier can be made with sticky gum products that are applied directly on the tree bark, such as Tree Tanglefoot, Roxo Bug Glue, and Bug Gum Mastic Barrier. Sticky tape products are also available – the best type for rough bark is an aluminum foil called Repel'm II or III. Barriers are most effective when placed around the trunk by the first week in April. The barrier should be checked at least once a week, and removed when caterpillars are not seen for several days (probably around the end of June). To capture larger gypsy moth caterpillars in trees, place a burlap hiding band above the tape or sticky trap in early May.

  Barriers should be at least two inches wide and not be easily torn. The adhesive on the underside of the band must securely adhere to the tree bark surface and be pliable enough to fit snugly into cracks and crevices. The sticky material on the outer surface of the band must retain its tackiness for the entire period of gypsy moth activity, without runoff because of warm temperatures or rain. Repair or replace any barrier that becomes separated from the bark; periodically check the barrier bands for dirt, trapped insects and other debris. Remove large insects, silken mats and debris to keep the barriers sticky, or, if it is easier, replace the barriers themselves.

- Place **burlap hiding bands** around tree trunks to reduce the number of wandering caterpillars and detect very low population levels. To make a burlap hiding band, wrap and tie a strip of burlap about 12" wide around the trunk of the tree about 5' off the ground. Fold the upper burlap portion down over the tie. The larger caterpillars will come down the trunk to hide during

the daytime and can be captured and killed in soapy water. You must destroy the caterpillars daily from May through June for this method to be effective.

- **Natural predators** help to control gypsy moth populations, such as birds, spiders, beetles, flies, and wasps.

LEAST-TOXIC

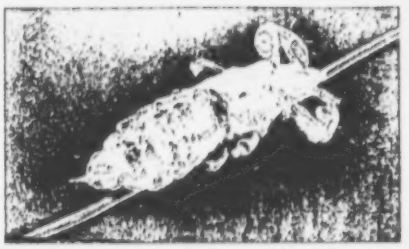
- If populations of gypsy moths get high enough that an insecticide is necessary, ***Bacillus thuringiensis*** **(Bt)** is an option. This biological pesticide is a bacterium that attacks the gypsy moth caterpillar. It is very effective if applied properly and can be applied by commercial applicators. It should be used only after all caterpillars have hatched, but before they get to be about one inch in length, and good leaf coverage is essential. Two applications are necessary, five to seven days apart. Bt is harmless to predators of worm pests and allows the populations of natural predators to grow, resulting in less of a need to spray and less chemicals needed when spraying occurs.

  As with any pesticide application, use extreme caution when applying Bt. It is non-specific and causes fatal disease in many species of butterflies and moths that are non-target and even beneficial or rare organisms. Use it only as a last resort when all other control tactics have failed.

Dimilin™, active ingredient diflubenzuron, has been widely used in gypsy moth control. An insect growth regulator, it inhibits the ability of the insect to produce its hard, chitin exoskeleton. Though it is relatively non-toxic in terms of its short-term effects to mammals by both oral and dermal routes, it has been shown to adversely affect the oxygen-carrying capacity of blood and may depress testosterone levels. It is also being scrutinized for its carcinogenicity because of "strongly suggestive evidence" that one of its breakdown products (4-chloroaniline) causes tumors in mammalian systems. Dimilin™ is extremely toxic to a wide variety of beneficial insects that help control the populations of pest insects, including gypsy moths, and also to many invertebrates, including many aquatic organisms that are essential parts of the food chain or commercially important, such as the blue crab.

The chemical will wash off of foliage and persist in the environment for longer than 90 days, yet there are still many unanswered questions about how far it will travel in surface water and whether its use poses a threat to bodies of water like the Chesapeake Bay.

HEAD LICE MANAGEMENT



IDENTIFICATION

Head lice (*Pediculus capitis*) are bloodsucking, parasitic insects that primarily feed on humans. The adults grow to be from 1-3mm long and are typically reddish-brown in color.

The female adult can lay anywhere from 50-100 eggs (nits) in her lifetime. With cement-like glue, she attaches each nit to a hair shaft, where they will hatch in 8-11 days. The hatched lice will take another 8 or 9 days to become adults, and, a day later, the female can begin laying eggs. The adults live for 9-10 days, making the entire lifespan of a louse at least 24 days.

HABITAT

Lice are usually found on the scalp, mainly around the ears and at the nape of the neck, but can also be found on eyebrows, eyelashes and other body hairs, on hats and scarves, and on combs and brushes. Generally, they can only survive off of a host for about 2-3 days without a blood meal.

PREVENTION

- Have children establish a no-sharing policy with their friends and classmates when it comes to commonly infested items, such as combs, brushes, hats, scarves, pillows, and blankets or mats at rest time or at home.
- If your classrooms have cubbies or coat hooks that are shared or clustered, have students place their coats and hats in sealed plastic bags to keep wandering adult lice away.
- Recommend that parents of children with long hair braid it before school and comb it out upon their arrival home.
- Inform parents as soon as you discover a child has lice so that they may begin taking preventive and control methods.

INSPECTION

- Watch for symptoms of head lice: head scratching, sometimes leading to scalp damage; red bites on the scalp, around the ears, and at the nape of the neck; and the presence of nits in the hair.
- Periodically check students for nits whether or not he or she is showing symptoms of head lice, especially if there has been an outbreak. Viable nits will be yellowish to grey in color, darkening to a tan or coffee color as they

mature, and are shaped like a tear drop. One sure way to distinguish nits from dirt, dandruff, lint, or any of the other plethora of things that manage to find their way into kids' hair, is that they will not flick or brush out.

CONTROL

NON-TOXIC

Nit Picking
Nit picking takes time and patience, but no head lice chemical effectively kills all nits, so combing is always going to be necessary. It is the safest and most effective method of treating an infestation.

- Liberally **apply coconut oil** to the child's head and scalp. (Any oil should work. It functions as a lubricant to make combing easier and smothers the lice.)
- Once the hair and scalp are thoroughly coated, **comb** through her hair with a wide-toothed comb to remove tangles and straighten the hair.
- Separate hair into one-inch sections and **search** thoroughly, both visually and by nit combing. Be careful — because the nits are tightly cemented to the hair, the comb may pull the hair out rather than merely remove the nit.
- **Immerse any nits or lice in hot soapy water** as they are pulled from the hair.
- Pin cleaned sections of hair aside, curling it close to the head.
- Periodically **clean hair and debris out of the comb** with a tissue, placing the tissue in hot, soapy water when it is soiled.
- Once finished, **wash the child's hair with hot water and blow it dry** (remembering that his or her head is much more heat sensitive than yours.)
- **Recheck** the entire head for stray lice and nits.
- **Clean out your nit comb**, removing any stray hair and nits, and soak in 150•F water for 15 minutes before putting it away.
- **Repeat** on every student or staff member showing symptoms of head lice for 12 consecutive days.
- Continue to **monitor** the staff and student body while and after you are treating those infested.

Cleaning
Lice don't generally infest homes or schools.

- A thorough **vacuuming** of all carpets, upholstery, and common space will take care of any fallen nit-carrying hairs or runaway lice.

- **Wash** all towels used during nit-picking sessions and other questionable items in hot (140•F/60•C) and dry on high to take care of any potential re-infesters.

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- **Place non-washables in the hot drier** for 20 minutes or have them dry cleaned. (You can also store the items in a plastic bag for 14-30 days, or freeze them in temperatures of -4• F (-20•C) for 5 hours, or -5•F (-15•C) for 10 hours.)

Where can I find a nit comb?
If your local drugstore doesn't carry metal-toothed nit combs, you can get the Licemeister® nit comb from the National Pediculosis Association, P.O. Box 610189, Newton, MA 02461, 781/449-NITS, www.headlice.org; or the Derbac ™ comb from Cereal Soaps Company, Division Johanson Manufacturing Corp., Box 329, Boonton, NJ 07005, 201/334-2676. A dog or cat flea comb may also be effective in a pinch.

LEAST-TOXIC

It will always be necessary to nit comb, no matter what course of treatment you decide upon, but if you feel a need to do more than oil and comb, there are enzyme treatments for head lice. Molting insects produce enzymes to lift open their exoskeletons when they molt. These products work by prematurely breaking apart the outer covering of lice and loosening nits from the hair. Due to the insects' need for these enzymes, they do not appear to become resistant to them. They are advertised as non-toxic to humans, but as with any pest control product, you should be sure to obtain full disclosure of all product ingredients before use. Enzyme treatments include Not Nice to Lice, 909/372-9850, www.safe2use.com, and Lice B Gone, Safe Effective Alternatives, Inc., P.O. Box 528, Belleville, IL 62222, 877-730-2727, www.licebgone.com.

PROBLEMS WITH CHEMICAL CONTROL

- Lindane, the active ingredient in Kwell®, a commonly prescribed lice shampoo, is readily absorbed through the skin on the scalp. It is a possible human carcinogen, and has been linked with blood disorders, and neurological and immunological effects. It has been banned for use in lice and scabies treatment in California. Nix®, contains permethrin, also a possible human carcinogen and a neurotoxin, which has been reported to cause temporary nervous disorders in the hands or face.

- There is widespread resistance of head lice to Lindane and permethrin, rendering these products useless in some cases.

HEMLOCK WOOLLY ADELGID MANAGEMENT

IDENTIFICATION

The hemlock woolly adelgid is an important pest of hemlock trees, which are extensively planted in urban landscapes. The pest was first reported in the eastern United States in the late 1960s – it's origin unknown.

It is a small, aphid-like insect with piercing-sucking mouthparts, which are used to suck sap from plants. For most of its life, it is covered by a secreted white, woolly substance. They feed primarily on young branches, causing cessation of tree growth, discoloration and premature drop of needles, the dieback of branches and possible death of the tree in as little as one year.

Hemlock woolly adelgid is parthenogenetic, meaning that all individuals are females. Adults are oval, blackish-grey, and about 2mm in length. During March and April, adults of the overwintering generation lay about 100 brownish-orange, very small, oblong eggs in a cottony mass on the young twigs. Nymphs hatch from the eggs during a period of several weeks from April to May. Within a few days, they disperse from the tree or settle on the twigs near the base of the needles, where they insert their piercing and sucking mouth parts. They will feed and remain here throughout their development. The spring generation matures by mid-June. Some of the adults produced will have wings and are unable to reproduce on hemlocks; they leave the hemlocks and go in search of spruce trees. Others are wingless and able to reproduce on hemlocks, laying about 100 eggs each in a cottony mass on the twigs in the middle of June. Crawlers hatch in early July and settle on the new growth. They will soon become dormant until the middle of October when feeding resumes. Nymphs feed and develop during the winter and mature in the spring.

The small size of the adelgid and the woolly nature of its egg masses and life stages predispose it to dispersal by both wind and migratory birds and mammals.

Hemlocks are injured when insects feed on the sap and inject toxic saliva into the tree. This dries out the needles, turning them a grayish-green color, and causing them to drop from the tree within a few months. Most buds are also killed, so little new growth is produced on infested branches. Death of major limbs usually occurs within two years and progresses from the bottom of the tree upwards,

even though the infestation may be evenly distributed throughout the tree. Trees often die within four years, but some survive longer in severely weakened conditions with only a sparse amount of foliage at the very top of the tree. The weakened trees have little chance for recovery and often fall victim to wood-boring insects, diseases, and are easily damaged by the wind.

HABITAT

The hemlock woolly adelgid is found throughout the United States.

PREVENTION

Cultural

- Discourage birds, squirrels and deer – all important dispersal agents – from visiting hemlocks.
- Take care when moving plants, logs, firewood or bark chips from infested areas to non-infested areas, especially from March to June when adelgid eggs and crawlers are present.
- Clean vehicles and clothing after visiting forests, recreational areas, parks or other properties with infested hemlocks.
- Selectively remove some large, mature hemlocks, which serve as reservoirs for the adelgid, to retard the establishment of new infestations.
- Maintain good growing conditions for existing hemlocks:
    - Water as often as needed, especially during drought, as it is a shallow-rooted tree. Ensure that it receives at least one inch of water per week, including rainfall, over the area beneath the drip line of the crown. Water should be applied slowly so that roots are well watered.
    - Prune dead and dying branches and limbs from the hemlock to promote new growth and allow more light to reach the foliage.
    - Avoid fertilizing hemlocks, as nitrogen enhances adelgid survival and reproduction. Fertilizing a tree after adelgids have been controlled may encourage growth and stimulate recovery.

Biological

- Plant resistant hemlock species. Two Japanese hemlock species, *Tsuga diversifolia* and *T. sieboldii* and two western North American hemlock species, *T. heterophylla* and *T. mertensiana*, are resistant to hemlock woolly adelgid. Although the adelgid infests these resistant species, it rarely reaches high enough densities to cause damage. Planting these reisitant hemlocks may reduce the impact of the insect in the ornamental landscape.

INSPECTION

Infestations can be detected early by periodically examining young twigs for the presence of the egg sacs and the presence of a white cottony scale on the hemlock branches, particularly in spring on the undersides of new growth. Egg sacs are readily observed in the spring before the eggs have hatched. Keep in mind that remnants of old egg sacs may remain on twigs long after the eggs have hatched and the insect has been controlled. Other signs of infestation may be the thinning or grayish-green color of the needles on some branches. Early detection is very important because injury to hemlock may develop quickly.

CONTROL

Proper timing is key for control of the hemlock wooley adelgid.

NON-TOXIC

- Eggs and crawlers are easily dislodged from trees by the wind and rain, and most are unable to find their way back into the tree and die. **Intentionally dislodging eggs and crawlers** by directing a strong stream of water at infested branches periodically from April through June may be of value in reducing adelgid numbers.

- **Clipping** the more heavily-infested twigs from hemlock branches will reduce adelgid density on a tree, but extensive clipping may have undesirable effects on the health of the tree.

LEAST-TOXIC

- **Horticultural oils and insecticidal soaps** have shown to be very effective when sprayed during susceptible life stages. 100% mortality was obtained by both materials when sprayed in mid-July (when all individuals were present as dormant nymphs) and in late October (after the nymphs had resumed development). Both of these materials are of relatively low toxicity, but will kill a wide variety of insects and mites, including those that are beneficial. They should only be used when the adelgid is present in damaging numbers.

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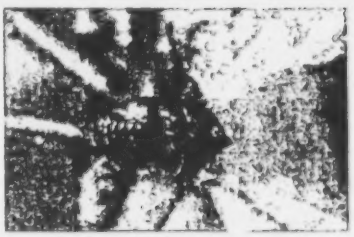
JAPANESE BEETLE MANAGEMENT

IDENTIFICATION



Japanese beetles are important landscape pests as both adults and in their larval stage, as grubs. The adult beetle is approximately ¼- to ½-inch in length, with a greenish bronze head and prothorax and the brownish-brown wing covers with green along the sides and center. They have 12 white tufts of hair present along the sides of the abdomen and at the tips of the wing covers. Their long legs have large claws.

Adults live four to six weeks, with their maximum abundance occurring early in July in most areas. They are active during the day, leaving their earthen cells to feed and mate in the morning and returning to the soil in late afternoon.

Mated females lay approximately 60 eggs during their lifetime, burrowing about three inches into the ground to lay their eggs, usually in grassy areas, such as turf, pastures and meadows, and in close-cropped grass. Eggs must absorb water to support the embryo, so a moist site is essential.

The white, elongate eggs hatch into grubs in about two weeks. They feed approximately eight weeks, until they are nearly full grown, until it pupates in May or June, emerging as an adult in summer. The life cycle usually takes one year, but can take longer in colder climates.

Adults feed on the leaves of plants, leaving them skeletonized and with large, irregular holes.

HABITAT

The beetle originated in Japan, where it is only a minor pest. It was first discovered in the United States in New Jersey 1916, where the beetle found a climate similar to that of their native Japan and large expanses of lawns and pastures in which to develop. The natural enemies that kept the beetles under control in Japan were not available in New Jersey, allowing populations to build to extremely high level.

Today, the Japanese beetle is found in practically all states east of the Mississippi, and is a periodic invader in California and other states.

PREVENTION

Cultural

- Control grubs in the lawn before they have a chance to become adult beetles. See *Grub Management* fact sheet earlier in this section.

Biological

- Keep use of garden pesticides to a minimum to protect natural enemies of Japanese beetles.
- Plant plants that will repel adult Japanese beetles.The adults do not like to feed on ageratum, arborvitae, ash, baby's breath, garden balsam, begonia, bleeding heart, boxwood, buttercups, caladium, carnations, Chinese lantern plant, cockscomb, columbine, coralbells, coralberry, coreopsis, cornflower, daisies, dogwood (flowering), dusty-miller, euonymus, false cypresses, firs, forget-me-not, forsythia, foxglove, hemlock, hollies, hydrangeas, junipers, kale (ornamental), lilacs, lilies, magnolias, maple (red or silver only), mulberry, nasturtium, oaks (red and white only), pines, poppies, snapdragon, snowberry, speedwell, sweet pea, sweet-William, tuliptree, violets and pansy, or yews (*Taxus*).
- Do not plant, or get rid of existing plants, that attract Japanese beetles. They enjoy American linden; crabapple trees; apple trees; Japanese maples; Norway maples; roses; crape myrtle; pin oak trees; birch trees; plum, apricot, cherry, and peach trees; black walnut trees; willows; grapes; horsechestnut; althea; asparagus; highbush blueberry; sassafras; Virginia creeper; and summersweet.

INSPECTION

- Monitor your lawn for signs of grubs, as described in *Grub Management* fact sheet earlier in this section.
- Inspect plants for signs of Japanese beetle damage and for beetles themselves.

CONTROL

NON-TOXIC

- **Attract native species of birds to your yard**, such as starlings, meadowlarks, cardinals and catbirds, which will readily feed on adult beetles.

- **Parasites**--Releasing natural enemies or parasites of an exotic insect is a successfully proven method to reduce pest populations. Two parasites of the Japanese beetle have been brought to the United States from Asia. Researchers have successfully established these insects in areas inhabited by the Japanese beetle, and the parasites are now functioning as important biological control agents of the beetle.

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Tiphia vernalis, a parasite of the Japanese beetle grub, and *Istocheta aldrichi*, a parasite of the adult, have been shown to be important in regulating the population dynamics of the beetle in the Northeastern United States. These parasites are not yet commercially available; however, you can contact your local extension agent to see if they are established in your area. If they are, planting the appropriate food plants will attract these parasites and increase the rates of parasitization, and thus help control the Japanese beetle on your property.

Tiphia vernalis--This small, parasitic wasp of Japanese beetle grubs resembles a large, black, winged ant. Its current distribution is believed to be throughout the Northeastern United States and south to North Carolina. After a brief period of feeding and mating during the spring, the female wasp digs into the soil, paralyzes a beetle grub by stinging, and then deposits an egg on the grub. When the egg hatches, the emerging wasp larva consumes the grub.

Food sources: Adult wasps of this species feed almost exclusively on the honeydew of aphids associated with the leaves of maple, cherry, and elm trees and peonies. In North Carolina, the nectar of tulip poplars has been found to be an important food source for the adult wasps.

Istocheta aldrichi--This solitary fly is an internal parasite of the adult Japanese beetle. The female flies are capable of depositing up to 100 eggs during a period of about 2 weeks. The eggs are usually laid on the thorax of the female beetles. Upon hatching, the maggot bores directly into the beetle's body cavity, killing the beetle. Because it does not take this fly long to kill the beetle, *I. aldrichi* can suppress Japanese beetle populations before beetles can reproduce.

Food sources: *I. aldrichi* is commonly seen feeding on aphid nectar deposited on Japanese knotweed (*Polygonum cuspidatum*), a persistent perennial weed native to Japan.

- **Hand removal of adult beetles.** Hand picking can be effective in reducing light infestations of adult beetles on shrubs bordering the lawn. Any method that reduces the number of adult females, particularly early in the season, will tend to reduce the grub population, and, therefore, reduce the adult population the next year. Try shaking the beetles from the plants before 7a.m. on cool mornings when they are still sluggish. They will drop to the ground, feigning death. Place a drop cloth under plants to easily collect the dropped beetles and immerse them in soapy water to kill them.

- **Vacuum adult beetles.** A small vacuum with a disposable bag can be used to

collect adult beetles. Early in the morning is again the best time for collection. Place the paper vacuum bag in a plastic bag and leave it in the sun to kill the beetles or drop it in a bucket of soapy water.

- **Trapping.** Japanese beetle traps baited with food and/or adult sex pheromones have been on the market, but can actually attract more beetles than they catch if only a few traps are used. Researchers at the University of Kentucky found that, if only one or two traps are used in a garden, as few as 54% of the beetles are captured and there is a net increase in beetles in the area around the traps. The experiment also showed no change in the number of grubs in the soil around the traps despite the large number of beetles found in the traps. Other studies have shown mass trapping to e effective at reducing adult beetle populations when large numbers of traps are used throughout an entire neighborhood. The traps should be placed every 200 feet around the perimeter of the area to be protected. This way the beetles are captured as they fly into the protected zone.

LEAST-TOXIC

- **Neem oil**, such as Margosan-O®, acts as an antifeedant and insecticide when sprayed on plants preyed upon by Japanese beetles. The beetles refused to eat and starved to death. It could also be used on foliage adjacent to lawns to discourage adult beetles from remaining in the area.

MOSQUITO MANAGEMENT

IDENTIFICATION

There are more than 2,500 different species of mosquitoes in the world, 150 of which occur in the U.S., and only a small fraction of which actually transmit disease.

Aedes are painful and persistent biters. They search for blood meals early in the morning, at dusk, and in the evening. They don't usually enter homes, prefer to bite humans, and are known to fly many miles from their breeding sources.

Culex are also painful and persistent biters, but prefer to attack at dusk and after dusk, and readily enter homes for blood meals. They usually prefer domestic and wild birds to humans and other mammals, and are known to transmit encephalitis. They are weak fliers and do not move far from their breeding site, staying within two miles. They live only a few weeks during the warm summer months. Females that emerge in late summer find sheltered areas in which to hibernate or overwinter until the following spring, when warm weather will bring them out again.

Culiseta mosquitoes are moderately aggressive biters, attacking in the evening or in the shade during the day. *Psorophora, Coquillettidia,* and *Mansonia* species are becoming more of a pest as the expanding human population invades their natural habitats. *Anopheles* mosquitoes are the only mosquitoes that transmit malaria to humans.

Mosquitoes go through four stages in their life cycle – egg, larva, pupa, and adult. Eggs can be laid either one at a time or in rafts and float on the surface of the water. *Culex* and *Culiseta* species stick their eggs together in rafts of 200 or more, which looks like a speck of soot floating on the water, about ¼-inch long and 1/8-inch wide. *Anopheles* and *Aedes* species do not make rafts, but lay their eggs separately. *Aedes* lay their eggs on damp soil that will be flooded by water. Most eggs hatch into larvae within 48 hours.

Larvae live in the water and come to the surface to breathe. They feed on micro-organisms and organic matter in the water. They molt four times, growing larger after each molting, and changing into pupae after the fourth molt when they are about ½-inch long.

The pupal stage is a resting, non-feeding stage. This is when the mosquito turns into an adult. It takes about two days for the adult to fully develop, split the pupal skin and emerge.

Adults rest on the surface of the water to allow their body parts to harden and wings to dry. The complete life cycle can take as little as four days or as long as one month, depending on the temperature. Only adult female mosquitoes bite animals and require blood meals; males feed on the nectar of flowers.

Sensible control strategies involve reducing breeding sites, which provides long-term control over mosquito populations, and controlling mosquito populations during aquatic stages, before they mature and have a chance to reproduce, transfer disease, and annoy. Larvaciding allows control measures to be conducted over the smallest possible area when mosquitoes are concentrated in breeding pools, before adults spread throughout the community.

Adulticiding programs do not get at the mosquitoes until they have matured and are already a nuisance, and do little to restrict breeding. Mosquitoes develop resistance to chemical pesticides over time, which render the chemicals ineffective. Adulticides also present considerable risk to all living things, and kill beneficial insects and natural mosquito predators, such as dragonflies, damselflies, and beetles.

HABITAT

Mosquitoes are dependant on suitable aquatic breeding habitats to complete their life cycle.

PREVENTION

Cultural

- Maintain window screens and doors, closing all opened doors.
- Remove or drain all tin cans, pet dishes, buckets, holes in trees, clogged gutters and down spouts, old tires, birdbaths, shallow fishless ponds, and other water-retaining objects.
- Stock permanent water pools, such as ornamental ponds, with mosquito larvae eating fish.
- Fix dripping outside water faucets.
- Enhance the drainage of flood canals, irrigation ditches and fields; keep street gutters and catch basins free of debris and flowing properly; and enhance drainage or create permanent deep pools in marshes.
- Remove or treat sewage leaks and lagoons, which provide excellent breeding conditions for certain species.

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- Use herbal repellents to ward off mosquitoes, such as Skin-So-Soft or Herbal Armour. Reapply often. Herbs that repel mosquitoes include cedarwood, garlic, lemongrass, frankincense, cinnamon, geranium, eucalyptus, basil, rosemary, cloves, peppermint, lemon balm (citronella), onions, feverfew, thyme, and marigold.

- Essential oils of the herbs listed above are also good repellents, though most are volatile organic compounds and will bother someone who is sensitive to scents. To mix your own essential oil repellent, add 10 drops of essential oil to 2 tablespoons of vegetable oil, stir, and dab a few drops on your skin or clothing. Pregnant women should consult their doctors before using essential oils.
- Neem oil, used as a mosquito repellent cream and composed of 2% crude neem oil is a highly effective repellent. In various studies, its protection against the *Culex quinquefasciatus, Aedes* sp. and *Mansonia* sp. was greater than 75%.

  Avoid repellents containing DEET, which is quickly absorbed through the skin and has caused effects ranging from large blisters to brain damage in children, three of whom died in the last 40 years. Studies have also found adverse effects from DEET mixed with permethrin, an insect commonly used for mosquito control, especially in spray programs. The combination of products caused the death of a large number of brain cells within the cerebral cortex, which controls muscles and movement, the hippocampal formation, which controls memory, learning and concentration, and the cerebellum, which synchronizes body movements. (For more information about DEET, see the chemWATCH factsheet on page XX.)

INSPECTION

Check ponds and sources of water for signs of mosquito larvae.

CONTROL

NON-TOXIC

- Burn **citronella candles** and torches to control mosquitoes in the immediate vicinity when there is no wind.

- The **Mosquito Magnet**, a machine much like a gas grill, burns propane gas that sends out a plume of carbon dioxide. The carbon dioxide attracts mosquitoes, which are then sucked in and killed. One magnet can control adult mosquitoes over an acre of land, though different levels of success have

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been reported. For more information see www.mosquitomagnet.com or call American Biophysics Corp. at 877-699-8727.

- Stock ornamental ponds with **mosquito larvae-eating fish**, such as mosquito fish of the *Gambusia* genus. They should be stocked in enclosed water so they will remain in the area in need of control. Only indigenous species should be used. Mosquitofish have a number of advantages over such things as goldfish and koi for biological mosquito control in ponds and other water sources: they actually eat mosquito larvae; they are voracious surface feeders with upturned mouths specially designed to get mosquito larvae where they live; they prefer the cover and protection of shallow overgrown areas along the shore which are also the preferred environs of mosquito larvae; and since they give birth to live young (they are in the guppy family) they don't need any special sand or other substance for spawning. They are self-sustaining and self feeding. You can order mosquito fish through J. Reilly, 5000 Trenton Street, Metairie, LA 70006, 504-887-3666; Natural Pest Controls, 8864 Little Creek Drive, Orangevale, CA 95662, 800-873-1252; or Richmond Fisheries, 8609 Clark Road, Richmond, IL 60071, 815-675-6545.

LEAST-TOXIC

- ***Bacillus thuringiensis* var. *israelensis*** is one of the most popular and most effective least-toxic biological controls. It is a bacterial strain that, when sprayed into larval pools, is ingested by feeding larvae and kills them. You can buy a product called Mosquito Dunks™ at your local lawn and garden store, in hardware stores, and in some catalogs and on line from Real Goods, www.realgoods.com, 800-762-7365 and Peaceful Valley, www.groworganic.com, 888-784-1722. The dunks are safe for birdbaths, rain barrels, ponds, ditches, tree holes, roof gutters, unused swimming pools -- anywhere water collects

- **Horticultural oils** (vegetable based) are effective in killing larvae in water and sinking egg rafts on the surface. They also can kill non-target organisms including some mosquito predators that breathe from the surface.

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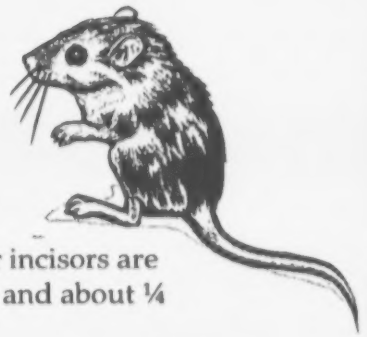
MOUSE MANAGEMENT



IDENTIFICATION

The house mouse's body is brown to gray, about 3 to 4 inches long, and weighs only about ½ ounce. It has a semi-naked, dark tail about the length of its head and body combined, large ears and eyes in proportion to its head, and a pointed snout. Its upper incisors are flat and notched, and its feces is rod shaped, pointed at the ends, and about ¼ inch long.

Mouse populations will grow as large as their food, shelter, and other competing species will allow. No matter what method of control you choose, the only way to permanently rid yourself of a mouse problem is to remove their access to the food and shelter that you are providing.

PREVENTION

A full-grown mouse can enter your house through a hole the size of a dime. They are talented climbers and able to swim, but do not need water to survive. (They get water from their food.)

Structural

- Stuff holes in and around the house with steel wool or copper mesh, or fill them with caulk or plaster and cover with sheet metal, paying particular attention to the foundation and holes between the house and garage.
- Seal gaps around the doors by replacing worn thresholds and weatherstripping, and installing door sweeps.
- Caulk openings around water pipes, electric wires, cables, and vents.
- Use hardware cloth to screen vents, floor drains, and any other openings.

Cultural

- Raise woodpiles at least 12 inches from the ground (and pet cages, if mice find them interesting), and wrap the legs in galvanized sheet metal to prevent the mice from climbing them.
- Cut tall grass, weeds, and brush from around the foundation and dispose of the clippings.
- Discard or recycle unused clutter around the house that may be providing a home for mice.
- Pick up fallen fruit and rotting vegetables from the garden, and don't place food scraps at the top of the compost pile.
- Store birdseed in a sealed container, use a birdfeeder with a catch tray, and clean up around it regularly.

- Store trash, indoors and out, in a metal container with a tight cover or fastener for the lid.
- Don't leave food on counters or dirty dishes in the sink overnight.
- Keep the stovetop, oven, broiler, and kitchen floor clean (especially under the stove and refrigerator).
- Store grains, cereals, nuts, and pet foods in sealed plastic, metal or glass containers, or keep them in the refrigerator.
- Pick up any uneaten pet food before going to bed.

INSPECTION

Identifying a mouse problem may be as easy as finding one scurrying across the linoleum or finding droppings on the counter.

- To be certain, sprinkle the surface that you suspect that they are frequenting with a light coating of flour. If correct, you'll find footprints in the flour and tracks from the flour, hopefully, to their point of entrance.
- Be more aware of possible mouse activity in the fall, when the cold weather hits, paying particular attention to areas where food is stored. Watch for mouse activity outdoors, in areas adjacent to houses, which may be the first sign of an impending onslaught.

CONTROL

NON-TOXIC

Physical controls

- **Have-a-Heart Traps** are "live" traps are meant to capture the mice so that you can release them instead of killing them. They are usually metal mesh with doors at either end. You can find this type of trap at your local hardware store, or contact Beyond Pesticides/NCAMP for a list of resources. Be sure to release mice far enough away from your house that they won't return and block off their point of entry to prevent any further infestation.

- If you use **snap traps**, purchase traps that have expanded triggers that snap when a mouse runs over them, even when unbaited, and a clothespin-like closing mechanism, which is thin enough to allow the bait pan to be bent by hand, allowing for the regulation of trigger sensitivity. Your chances of catching your mouse are greater with a more sensitive trigger.
  - Set baited traps out for a few days without setting the triggers, as mice are wary of new objects in their environment. You will also have a chance to see if your bait is disappearing, indicating that you have chosen a good location for your traps and bait that your mice enjoy. If there is no sign

that your bait has been eaten, move your traps to a new location. If that doesn't work, then change your bait.

- Mice tend to scurry along the walls, often referred to as runways. Traps should be positioned at a right angle to the wall, with the bait end towards the wall. Place five to ten traps near mouse holes, one to two feet apart. If you are the lucky host to a multitude of mice, it is more likely that they will approach from more than two directions. Try setting the traps in pairs parallel to the wall, with bait pans facing outwards. Traps should always be handled with gloves, as mice are sensitive to the odor of humans. Coating the trap with bacon grease will also help to mask your scent.
- Bait should be sticky so that the mouse will disturb the trigger mechanism even if it only touches the bait lightly. Good choices include peanut butter mixed with rolled oats, raisins, gum drops, or even a small piece of cotton that your little friends will attempt to acquire for nesting material. Various baked breads have also had great success rates, with trap shyness minimized by alternating the type of bread used.

- **Glue traps** offend many people because they don't kill the mouse immediately and may trap nontarget species. They also get really stinky with that dead rodent odor if not checked daily. Glue traps do, however, catch both large adults and smaller mice, which frequently escape snap traps. They also are good for those hard-to-reach places or where it is difficult to gain access to mouse runways. Glue traps come as either flat boards, or in box or tube types. While the box or tube glue trap will protect against moisture or dust, mice are more reluctant to enter an unfamiliar enclosed object than to tread upon a flat, open object.
  - Glue traps should be in place for at least five days to allow enough time for the mice to become accustomed to them before you decide they are unsuccessful. They can be baited, with the bait placed in the center of the trap to ensure that the mouse establishes full contact.
  - Easiest clean up is often simply sweeping the successful trap into a garbage can, taking care not to touch it with your bare hands. Live animals trapped in the glue can be submerged in soapy water until dead.

  With any method of trapping, be sure to block the area off where you have set your traps to prevent your children, pets or any other nontarget species from getting hurt or exposed to nasty pathogens from the dead and live mice.

- **Repellent sound devices** disrupt the sound communication between mice and repel rodents by generating a sound that annoys them, but at a frequency that is not heard by humans. There is little scientific proof that this is an effective method of control, though there have been reports of success using these devices. One example is a solid-state electronic unit that uses a patented

method of directing variable pulsating frequencies onto a carrier, usually either the electrical wiring of a building or home, the metal gridwork within a building or the earth around the building, depending on where the unit is used. In your home, it would plug into a three-pronged electrical outlet and use the building's existing wiring to carry a variable, pulsating frequency that would distress your mouse visitors, causing them to leave. This system is designed to affect mice no matter where they are, between walls, in ceilings, and below floors. It is best used with another method of control for the first few months during the "flushing out" period, and when accompanied by habitat modification.

Biological controls.

- **Cats** may be effective in knocking off the occasional mouse, but it is unlikely that they will be capable of suppressing an established mouse problem.
  - If you decide to get a cat, females are more predacious than males, especially if they have a new litter or have been trained by a good mouser.
  - Only count on your cat to prevent initial mouse entry or to detect and remove new mouse colonizers, and remember that, in the small amount of time it lives in your house, a mouse may have time to contaminate food, destroy furnishings, or spread pathogens over clean dishes.

- Outside, the mouse has many **natural enemies**, including native hawks, owls, snakes, mites, ticks, fleas, flies, nematodes, bacteria, and viruses. Maintaining parks with wild areas within urban settings can encourage these beneficial organisms.

- Specific strains of *Typhtmurium*-like salmonella **bacteria** are used to control outbreaks of small field rodents in Russia. This is not, however, a practical resource for consumers.

TOXIC CONTROL

Rodenticides and Bait Boxes

Chemical mouse control includes rodenticides (baits and tracking powders) and bait boxes. Mice nibble rather than eat large quantities at a time, so any rodenticide that you consider will need to be used at high concentrations, which means an increase in the hazards to nontarget species. If you decide to use poisons, be sure to block off the areas where you have placed them to minimize the chance of an accident.

- **Bait boxes** are plastic or metal boxes with the anticoagulant bait placed inside. The bait is protected from the elements, humans and pets are more protected from unintentional exposure to the bait, and the amount of bait

being taken by the mice can be more carefully monitored. Bait boxes may also help increase the amount of food (and, with the food, poison) taken in by the mouse. Contact Beyond Pesticides for a list of resources for bait boxes.

- **Tracking powders** are extremely hazardous and should really be left to a professional pest control operator. Single-dose baits are high-concentration poisons. They are restricted materials that require a permit and can only be applied by professionals.

- The most commonly used household rodenticides are **multiple-dose anticoagulant baits**. These chemicals are ingested in smaller doses over several days, and essentially work by preventing the mouse's blood from clotting, causing it to bleed to death internally. There is still some risk of poisoning nontarget species, even with the lower doses of poison, and are also reports of mice becoming resistant to some of the most common of the anticoagulants — warfarin, chlorophacinone, bridufaciynm and bromadiolone.

RAT MANAGEMENT

IDENTIFICATION

The two major rat species are the Norway rat (brown, wharf or sewer rat) and the roof rat (black, ship or house rat).

The Norway rat, considered the most important pest rat in the U.S., occurs in every state and is widely distributed around the world. It grows to about 16 inches including the tail, which is dark above, pale underneath, scaly, and shorter than its head and body. The fur is brown with black and shaggy, the snout is blunt, ears are small with short hairs, and the fecal pellets are capsule shaped. Adults weigh around 11 ounces. They can climb and are excellent swimmers.

The roof rat can also grow to be about 16 inches including the tail. The tail is all dark, scaly, and longer than its head and body. The fur is grey to black and smooth, snout is pointy, ears are large and naked, and fecal pellets are longer and cylindrical. Adults weigh about 7 ounces. They can swim and are active climbers.

Domestic rats gnaw on electrical cables, water pipes, doors, window sills, walls, ceilings and floors, causing structural damage, and damage to insulation, containers and packaging materials. They also carry such diseases as murine typhus, leptospirosis, trichinosis, salmonellosis, ratbite fever, and the "black" or bubonic plague.

HABITAT

They are both omnivores and will feed on almost anything. They require water daily, and nest where water is available.

Norway rats generally build their nests in underground burrows or in ground level areas in buildings. They are most likely to occupy the first or basement floor of a building.

Roof rats prefer living in elevated areas, building nests in trees, vine-covered fences, and roofs, attics and walls, but will nest at ground level if arboreal habitat is limited. They often enter buildings from the roof or via overhead utility lines, which they use to travel form area to area.

Rats can: pass through any opening larger than ½ inch square; walk along horizontal wires and climb vertical wires (roof); climb the inside of vertical pipes 1 ½ inches to 4 inches in diameter; climb the outside of vertical pipes and conduits up to 3 inches in diameter; crawl horizontally on any type of pipe or conduit; jump vertically above a flat surface at least 36 inches; reach about 13 inches above a flat surface; dive and swim underwater for up to 30 seconds; swim up through the water seal or trap of toilets; swim up to ½ mile in open water; gnaw and leave marks on almost anything, including wood, chip board, lead pipes, cinder blocks, asbestos, aluminum, sheet metal, glass and adobe.

PREVENTION

Structural

- Prevent rat entry by burrowing by extending footings into the ground a minimum of 24 inches and making a concrete curtain wall with a horizontal extension that extends 12 inches outward. Ground floors should be 18 inches above the ground. They can also be constructed of concrete, stone and mortar, or brick and mortar.
- Place a termite shield between concrete and wood to prevent rodents from gaining access at these points.
- Construct floors of basements and outbuildings with reinforced concrete a minimum of 2 inches thick. If wood flooring is used, it should be lined underneath with ¼-inch by ¼-inch 19-guage wire mesh or hardware cloth.
- Place barriers between and within walls to prevent rodent travel. Open spaces between floor joists give rats free access to wall voids. Wooden 2x4 stops can be used on upper floors, but a noncombustible material should be used on lower floors. In new construction, good grade cement is recommended; galvanized sheet metal can be cut to fit and then nailed between studs, joists, floor and sill in older buildings.
- Make a rat-proof barrier between landscaping and adjacent buildings by digging an 8 to 12 inch deep trench and filling it with pea gravel. Rats dislike burrowing in the loose gravel.
- Plug any opening that is ½ inch or larger temporarily with steel wool, and then permanently with 19-guage or thicker galvanized metal sheeting, ¼ inch hardware cloth, or 22-guage or thicker aluminum sheeting. Do not use chewable materials, such as plastic and wood.
- Seal holes in foundations of buildings or entrances to rat burrows.
  - Use a minimum of 2 inches of reinforced portland cement mortar mixed with iron filings or broken glass pieces ¼- to ½-inch long. Get iron filings from a machine shop; smash glass in a tough paper bag with a hammer, and mix it into the mortar as you mix it. The glass or iron deters rats from digging out the mortar before it hardens. Use 3 ¾-inch thick mortar if you don't use the filings or glass.

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- Nail hardware cloth into the hole, and then cover it with mortar.
- Seal openings around pipes and wires that enter the structure through wood with metal collars. Use portland cement mortar where pipes pass through walls of brick or other masonry.
- Prevent rats from climbing up or moving along pipes or wires by installing guards and barriers. Use tin snips to cut a piece of galvanized sheet metal 36 inches square; then cut a hole in the center just large enough to fit the pipe snugly. The 18-inch border will prevent rats from jumping over the barrier.
- Rat-proof vent pipes by bending a square of ¼-inch mesh galvanized hardware cloth over the top and securing it with wire.
- If an existing structure has a wood floor near or directly on the ground, bury an L-shaped length of hardware cloth 24 inches deep, bring it 24 inches up the outside wall and fasten it there.
- To prevent rat access in dirt-filled areas, such as stables and storage sheds, lay metal hardware cloth on the ground and cover it with soil. Extend the edges of the cloth a minimum of 6 inches up from the soil and attach it to the fencing.
- Cap floor drains in basements so rats cannot enter through them. Install brass drain covers or perforated metal caps help on place by hinges so they can be opened for cleaning. Unhinged covers should screw in place. Place of ¼-inch mesh galvanized screen under existing drain covers to prevent rat entry if the hole is larger than ½ inch.
- Install flashing or metal channels on the lower edges of doors. Bend galvanized sheet metal in a U-shape to fit the lower edges of the door and affix it with screws. Clearance between the door and its threshold should be less than ¼ inch. Door casing should also be protected with sheet metal to prevent rats from widening cracks by gnawing. Frequently used doors should be equipped with mechanical self-closing devices.

Cultural

- Store foods, especially grains and nutmeats, in rat-proof glass or metal containers. Keep fresh fruit and vegetables in refrigerators or in open-air coolers screened with ¼ inch wire mesh. Consider storing all attractive food, including closed, packaged candy and crackers, in the refrigerator until rat problems are solved.
- Check grass seed, dry pet food, and other materials stored in sheds and outbuildings periodically for signs of rodent entry. For extra safety, place them indoors, or in metal or screened bins tough enough to withstand rat gnawing.
- Separate organic garbage from metal, glass and plastic at the sink. Avoid using electric sink garbage disposals, which can exacerbate rat problems by feeding them within the sewer system. Drain organic material and wrap it in newspaper before placing it in the garbage.

- Clean up any fallen fruit, nuts or garden wastes that may be attracting rats to the grounds as frequently as possible. Store excess garden produce in a rodent-proof manner.
- Clean up unfinished pet food and any bird-feeder spill.
- Use outdoor garbage cans with tight-fitting lids. Use spring fasteners to keep the lid tightly closed if the can is pushed over. Place cans in a rack that is elevated at least 12 inches above the ground, and maintain a distance of at least 24 inches between cans and structures from which rats may jump onto cans. Wash out garbage cans periodically.
- Make certain that dumpster lids seal tightly when closed and are kept closed when the dumpster is not in use. If the dumpster has drain holes, fit them with removable plugs or wire mesh screens to deny rodents easy access. Periodically hose out the container to rid it of any organic waste build up.
- Monitor dumpsters and outside waste bins daily, especially right before dark, cleaning up all misplaced material and closing the lids.
- Store lumber at least 18 inches above the ground on a rack.

INSPECTION

Regularly monitor the areas that rats are suspected of inhabiting. Thoroughly search attics, basements, foundation perimeters, crawl spaces, and behind and under stored materials. Note rat holes and create a map showing their location, approximating building sizes and garbage storage sites. Temporarily plug the holes with soil, sawdust or crumpled paper, and then return 24 hours later to see whether they have been reopened or the paper has been chewed or moved. If so, assume that the disturbed holes are active, record the information on the map, and determine your best management strategy.

Signs of rat infestation include:

- Droppings along runways, in feeding areas, and near the rats' shelter.
- Tracks, including footprints and tail marks, on dusty surfaces, in mud or in snow. Make artificial tracking powder with talcum powder sprinkled wherever you suspect rats are getting in – around doorways, broken windows and torn screens. Use as little powder as possible, and leave it in place overnight.
- Urine along traveled pathways or in feeding areas. Both wet and dry rat urine glows under ultraviolet light.
- Runs or burrows next to walls, along fences, nest to buildings, or under bushes and debris. Rats use the same routes habitually.
- Smudge marks or rub marks on walls, beams, rafters, pipes, and other fixtures (as a result of oil and dirt rubbing off the rats' fur along frequently traveled routes).
- Gnawing marks on doors or ledges, in corners, in wall material, on stored

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materials, or on other surfaces. Active infestations can be detected with fresh accumulations of sawdust, wood shavings, insulation and other gnawed material. Rats can also gnaw through rusty sheet metal. Gnawed entry holes are often two inches or more in diameter.

- Noises in the walls caused by gnawing, climbing, clawing, squeaks, and fighting, particularly at night when rats are most active.

CONTROL

NON-TOXIC

- **Traps** are considered the most humane method of rat control, as they kill rats more quickly than poison baits, and also eliminate the problem of carcasses rotting in walls and other inaccessible areas. Carcasses removed from traps can be incinerated or wrapped in plastic and placed in the garbage can. Kill trapped rats that are still alive by scooping up the rat and trap with a shovel and placing them in a bucket of soapy water.

  Spring-operated traps can be made more effective by expanding the trigger. Cut a 1½-inch square piece of stiff cardboard or •-inch thick wood and attach it to the existing trap trigger with wire or strong glue. These will often catch rats without bait if the traps are placed well and moved when necessary.

  Traps can be baited with pieces of hot dog, bacon, liver, fruits, raisins, marshmallow, or peanut butter mixed with rolled oats. If rats have shown preference for a particular food in the cupboard, give that a try. Tie the bait securely to the trigger (except the peanut butter).

  Traps should be left baited and unset for two to three days to allow rats to grow accustomed to their presence, and to determine whether or not they like the bait. Always use gloves when handling traps to prevent your skin oils from marking the traps, and to protect you from pathogens.

  Locate active rat holes, and set traps along the walls or other runways leading to the holes. Good locations also include near droppings, gnawing marks or other signs of rat damage; under and behind objects that may harbor rats; in dark corners; and along rafters or other protected areas where rats are likely to travel. Traps should generally be placed with baited triggers facing the wall, with two traps side by side to increase chances of success.

Rodenticides and Bait Boxes

Chemical rat control includes rodenticides (baits and tracking powders) and bait boxes. Any rodenticide that you consider will need to be used at high

concentrations, which means an increase in the hazards to nontarget species. If you decide to use poisons, be sure to block off the areas where you have placed them to minimize the chance of an accident.

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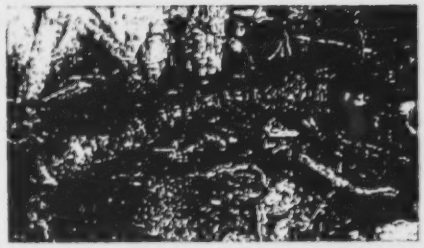
SOD WEBWORM MANAGEMENT

IDENTIFICATION



Sod webworms are the larvae of small, dingy brown or whitish moths. Only a few of the 60 to 80 species of webworms in the U.S. are lawn pests, the others preferring grain crops or wild grasses. The caterpillars are ¾- to one-inch long and, depending on the species, are grayish-brown, greenish, to dirty white with four parallel rows of dark brown spots on the abdomen. Adult moths have the characteristic habit of folding their wings closely about their bodies when at rest, earning the name "close-winged moths." The two finger-like horns protruding from the head give rise to a second common name, "snout-moths." If disturbed during the day, the moths fly erratically for a short distance before settling again on the lawn or adjacent shrubbery. The adult moths do not feed on grass.

In late spring and early summer, female sod webworm moths fly over lawn areas at dusk, dipping down to drop as many as 200 eggs in the grass. The eggs resemble tiny, cream-colored beads, and are preferentially dropped in humid areas of succulent grass. Eggs hatch in about four and a half days at 75 degrees. The eggs need moisture to develop, and if the area dries out, mortality will be high. The small worm produced can only skeletonize the soft interveinal surface parts of leaves. If the leaf is tough and hard, it may starve to death at this stage, or if a drop of water or rain hits the larva, it may wash off the leaf to the soil and be lost.

The first and second instar stages are usually spent on a single grass leaf. By the third instar, the worm is large enough to take bites from the edge of the leaf and the leaf appears notched. During the fourth, fifth and sixth instars, the worm constructs little burrows or tunnels covered with bits of dirt, lined with silk, and reinforced with their excrement and pieces of grass. They then cut off the blades of grass completely and drag them into their burrows, where they feed in safety and at leisure. When the larvae are about ¾-inch long and have completed their growth, they leave their burrows and construct cocoons of silk and bits of earth in the nearby soil. The moth emerges from the pupa in 10 to 14 days and forces its way from the cocoon into the open air.

Within a few minutes of emerging from its cocoon, the moth's wings are spread and dried and it is ready to mate and produce a new generation. Adults live only a few days and take no solid food.

Nearly mature caterpillars overwinter in the soil and resume feeding in the spring once temperatures begin to warm, in late April to early May. In northern and midwestern states, adults begin to emerge in late June to early July and can be seen flying across lawns at dusk. Pupation takes place in late June to early July, and second generation adults are usually observed shortly afterwards. New eggs are deposited and second generation adults can soon be observed. New eggs are deposited and second generation larvae reach peak activity in mid-to-late August – the point when most damage is observed. As temperatures drop in the fall, webworm larvae burrow deeper into the soil to overwinter. In warmer areas of the country, webworms may produce up to three generations. In western and southern states, webworm generations may overlap, with all life stages occurring simultaneously.

Damage may first appear as a dingy brown area in the grass, but as worms grow larger and begin eating entire leaves, large areas of grass can be severely damaged. As green leaves are removed, the brown turf is exposed and the infected areas are straw colored. The worms stay close to their burrows and tend to thin the turf in a circular area the size of a quarter or half dollar. The feeding areas appear as pick marks in the lawn.

HABITAT

Sod webworms live in the thatch layer of lawns. Eggs must be layed in moist soil, but larvae prefer dry, hot areas.

PREVENTION

Cultural

- If the lawn has more than ½- to ¾- inch of thatch, dethatch the lawn. This involves using a special metal rake to pull out and remove the dead material, followed by aeration of the lawn with a tool that removes plugs of soil.
- Make certain that the lawn is properly irrigated and that the soil is not compacted and interfering with the soil's ability to absorb water being applied. Aeration and application of ¼-inch layer of screened, weed-free compost will help correct the problems and allow grass to resume vigorous growth, replacing the damaged blades of grass.

Biological

- Encourage natural enemies of webworms - birds, parasitoids and a pathogen.
    - A small wasp-like insect called *Apanteles* (in the Braconidae family) deposits its eggs in the webworm. The parasitoid maggots emerge from their eggs and feed on the internal tissues of the hosts, causing their death. They emerge from the host when full grown spin their small white ellipsoid cocoons in a mass on the ground, and then

adult parasitoids emerge fro the cocoons to lay their eggs in other webworms.

- Two species of flies – *Phorocera claripennis* and *Zenillia caesar* – parasitize webworms. They deposit their eggs in the skin of the webworm larvae. Maggots hatch from the eggs, burrow into the bodies of the host larvae and feed there, eventually killing the worm.
- Vespid wasps, native earwigs, carabid, rove beetles, four species of ants, and a mite all feed on webworm eggs.
- The fungus *Bearvaria bassiana* attacks webworm larvae, truning them dull pink and flaccid. The fungus provides good control, but only after the larvae have caused significant damage. The impact of the fungus is not really seen until the following year when there are fewer overwintering webworms due to the larvae kill the previous fall.

- Replace or overseed the turf with naturally resistant lawn species, such as perennial ryegrasses and fine-bladed fescues that contain "endophytic" fungi, which prevent certain insects and lawn disease from feeding on the grasses.

INSPECTION

To determine if your turf is infected with sod webworms, check the layer of thatch just above the soil line. Webworms are present if:

- Grass blades in the damaged area are actually missing and not just dead;
- There are green fecal pellets in the thatch; and
- Larvae residing in silk-lined tubes are present in the thatch (use a small hand trowel to loosen the thatch to detect the tubes).

Soap drenches will force caterpillars to the surface, and are another effective monitoring tool. To accomplish this, mark off two or three sections of lawn two feet by two feet in both damaged and undamaged areas. Mix two tablespoons of liquid detergent into a gallon of water in a sprinkling can and pour it evenly over each marked area. The soap irritates the webworms, causing them to crawl to the surface in five to 10 minutes. Keep a close watch on each test area for about 10 minutes since brief movements alone may indicate webworms are present. Where thatch layers are thick, it may be necessary to pour several more gallons of soap solution on the test area in order to thoroughly saturate the thatch and reach the webworms. If the thatch is saturated and no webworms appear, the damage is probably due to disease or another type of insect. If insects do surface, check to be sure they are webworms.

It is a good idea to select several spots and monitor them once per month during the spring and summer to catch any developing problems. Two or three larvae

per square foot are probably not cause for concern. The presence of 10 or more in healthy turf is cause for action; however, if your lawn is under stress, the presence of even one larva per square foot usually indicates a need for treatment.

CONTROL

NON-TOXIC

- **Drench the soil** and the area adjacent to the damaged area with the soap solution described in the monitoring section. As soon as the caterpillars wriggle to the surface, rake them into piles with a flexible lawn rake, scoop them up and drop them into a bucket of soapy water.

- Let **poultry** roam around your lawn for a day – they will clean out a webworm infestation more quickly than any other method. After removing the poultry, thoroughly irrigate the lawn.

- **Beneficial nematodes** may be effective predators of webworms. Commercially available *Heterorhabditis* and *Neoplectana* nematodes show promise at reducing webworm populations when watered down into the thatch layer.

LEAST-TOXIC

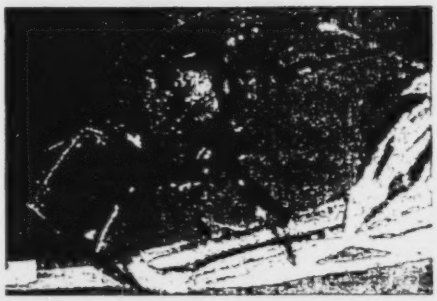
- ***Bacillus thuringiensis* (Bt)**, sold as Dipel®, Thuricide®, and Safer's BT®, is a naturally occurring bacteria that affects only caterpillars. It has no effect on the moth stage of sod webworms.

SPIDER MANAGEMENT

IDENTIFICATION

The most common poisonous spiders in the U.S. are tarantulas, black widows, and brown recluse or violin spiders.

Tarantulas are light to dark brown and typically about 2.5 inches long, though they can grow to 5 inches including the legs. Their abdomen and legs are covered in hair. They are basically harmless and will only bite upon extreme provocation. Their first line of defense is to rear up their hind legs and look fierce. They also have specialized urticating hairs on their abdomen that are tipped with venom and are brushed loose with their hind legs.



They are found in certain parts of the Southwest, from Texas through California, and north through Oklahoma, Colorado, Utah and Nevada. Young tarantulas either burrow in the ground or find a suitable hole to occupy in a protected location. They line their tunnels with silk and camouflage the opening with plant debris or soil. Once establishing a good nest, they do not stray for the many years it takes to reach maturity, when the male will wander to find a female. This is usually the only time they would enter a house and cause concern.

The adults of the three most common species of black widows in the U.S. are shiny black with a red design resembling an hourglass on the underside of the abdomen. The young spiders are whitish when they leave the egg and darken gradually, passing through stages where the black is mixed with white, yellow and red spots and bands. Adults grow to be about 9/16 inch long. They are not aggressive and rarely bite.

Black widows spin a small web of coarse silk with a tunnel in the center, where they will retreat when disturbed. Webs are generally spun close to the ground.

There are at least six species of brown recluse or violin spiders in the U.S., with a typical body length of 1/3 inch. They are tan to brown with a distinctive violin shaped darker marking on the top of the body near the head. Their legs are long and thin, and their bodies are smaller in relation to the legs than a black widow's.

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They prefer dark, undisturbed places near the ground for their webs. They will travel some distance from their webs to hunt, and will take temporary refuge in clothing or bedding, which is usually when humans are bitten.

HABITAT

Most spiders pose no threat to humans. Even the most dangerous spiders in the U.S. are not aggressive and can only be provoked to bite under certain circumstances. Spiders are actually beneficial biological control agents, preying upon a vast number of insect pests.

Webs usually only become visible when they are no longer in use and begin collecting dust. The only potentially dangerous web-building spiders occasionally found in the house, the black widow and the brown recluse or violin spider, are found in dark, hidden corners, usually near the floor, and not in light, open areas along the ceiling or around windows where spider webs are often noticed.

Spiders will often build webs in corners, under eaves and on shrubbery. Inside, they are most numerous in storerooms, crawl spaces and basements. They are attracted to places where there are large numbers of insects for food, and are therefore attracted to structures with security lighting, which attracts flying insects. Usually, there is little food available indoors, limiting spider populations unless there is easy access or food sources. Populations will fluctuate from year to year and will be the highest in late summer.

PREVENTION

Structural

- Install door sweeps.
- Seal electrical openings.
- Screen vents and seal around them.
- Seal up access points on the outside of buildings.
- Repair or tighten screens in doors and windows.
- Power wash the outside of buildings to remove debris.

Cultural

- Vacuum the floor, baseboards and corners regularly.
- Remove vegetation from around the building, leaving a 24-inch band.
- Move firewood, stacked lumber, stone, and other clutter from around the buildings' foundations.
- Remove, reduce or shield outside lighting. Use shielded lights, lower wattage

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bulbs, or sodium vapor or yellow lights.
- Indoors, use shades or curtains at night so that insects and spiders are not drawn to windows.
- Dry out and vent any moist areas, which may attract spiders.
- Remove clutter in storage rooms; keep boxes away from walls.
- Remove clothing from the floor and hang shoes or place them in sealed plastic bats. (Most spider bites are received when putting on shoes or clothing that has lain on the floor.)
- Shake out any clothing thoroughly that has been at ground level overnight.
- Thoroughly check and shake clean blankets or other bedding that have been undisturbed for long periods.

Biological
- Eliminate insect populations attracting spiders.

INSPECTION

Look for spiders crawling about or webs in corners, eaves, or outdoors in shrubs. An increase in insect pests may lead to an increase in spider populations and indicate a need for closer surveillance. Use glue board monitoring traps to follow spider activity and find problem spots.

- Monitor for black widows at night with a head lamp or flashlight, checking in cracks and crevices around the foundations of buildings, on the undersides of outdoor wooden furniture, between stones and flowerpots, and around the edges of woodpiles or other materials stored outdoors.
- Brown recluse spiders are most often found in boxer, around piles of paper and debris, in bedroom closets, under furniture, around woodpiles, sheds, and similar areas outdoors where debris may pile up.

CONTROL

NON-TOXIC

- **Vacuum** to remove webs and egg cases.

- **Invert a wide-mouthed jar over the spider** and slide a piece of stiff paper or thing cardboard under the jar while keeping the jar pressed against the surface on which the spider is standing. Keeping the paper pressed against the mouth of the jar, turn the jar over and tap the paper so the spider falls in the jar. Carry the jar outside and shake the spider out.

- **Freeze** boxes of papers suspected of harboring brown recluse spiders for 48

hours to kill the spiders before unpacking the boxes.

- Gently **sweep** up the spider (especially tarantulas), place them in a grocery bag and release outside.

LEAST-TOXIC

- You should not have to use poisons to rid your structure of spiders.

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SQUIRREL MANAGEMENT

IDENTIFICATION

Squirrels belong to the order Rodentia, the largest living group of mammals. There are seven native species of squirrels in North America, but the eastern and western gray squirrels are the species most commonly known and the worst pests.

Squirrels' most distinguishing feature is their long, bushy tail, which is used for balance when leaping and climbing, and are wrapped around their bodies as they sleep for warmth in the winter. Tree squirrels have extremely powerful legs that enable them to jump up six feet and leap between trees that are eight feet apart. They can run up to 19 miles per hour and can swim up to a mile at a time. Their powerful upper and lower incisor teeth grow throughout their lifetime to compensate for the intense wear that they endure. They have large eyes, good eyesight, acute hearing and a keen sense of smell, which enables them to find buried nuts that they or other squirrels have cached.

Eastern gray squirrels are 16 to 20 inches (41 to 51 cm) in length and weigh approximately 1-¼ to 1-¾ pounds (567-794 g). Their color may vary, being gray, reddish-gray, black and white (albino). The western gray squirrel is gray above with distinct white underparts. There is no discernable difference between males and females.

Tree squirrel diet consists mainly of cones, fruit, seeds, fungi, buds, shoots, flowers, bark and lichens. They occasionally also enjoy animal food, such as insects, birds' eggs and young, and even dead squirrels. The western gray squirrel primarily eats acorns, and most of its range includes oak trees of various species. It spends considerable time in autumn gathering and burying each acorn in a hold three to four inches deep, retrieving them later by smell.

Though they usually sit on their haunches to eat, squirrels can eat from any position, including upside-down. They are either right- or left-handed when handling food, and cache food, especially nuts, cones and fungi, when it is abundant.

Tree squirrels do not hibernate. They are dependent on the warmth of their nests to protect them from cold winter nights and very cold winter days. Their peak

activity times during the day in spring, summer and fall are the first two hours after sunrise and mid-afternoon.

HABITAT

Tree squirrels have four types of nests: winter dreys, summer dreys, dens and holes in the ground (pine squirrels only).

Dreys are twig and leaf nests built in trees, often by enlarging birds' nests, and lined with some type of soft material. Winter dreys take from one to several days to construct, are usually fairly elaborate, and are most often situated in the fork of a large branch. Summer dreys are much more simple and may be on exposed branches. Tree dens are cavities in the main trunks of trees and may be either nest dens or escape dens.

Their home range can be from 1 to 100 acres, depending on the season and availability of food. Some species are territorial, using scent marks, such as urine markings, to mark territory. They also mark travel lines on the ground and in the trees, which they use as paths. The marking points of gray squirrels are often found on the underside of large branches and may become darkly stained. Anal dragging and cheek or face wiping are other observed marking behaviors.

Food and weather permitting, female squirrels may have two litters per year, with two to six infants. Peak birth times are between the end of July and early August, and in the winter between late December and early January. They young are born hairless, blind and with their ears closed. After 7 to 12 weeks they are weaned and leave the nest, dissolving family ties. Squirrels in the wild often survive only ten to twelve months, but can live between seven and fourteen years.

PREVENTION

Structural

- Seal all holes in eaves and roofs that would allow squirrel entry, especially around attic fans, roof vents and in fascia boards behind gutters.

Cultural

- Trim tree branches back at least 10 feet from the building.
- Encircle isolated trees and power poles with a two-foot wide collar of metal six feet off the ground to prevent squirrels from climbing them. On trees, attach the metal using encircling wire held together with springs to allow for tree growth.

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- To prevent squirrels from traveling on wires, attach two-foot sections of lightweight 2 to 3 inch diameter plastic pipe. Slit the pipe lengthwise and put it over the wire. It will rotate on the wire, causing the traveling squirrel to fall.
- Place bird feeders well away from trees, fences or wires.
- Do not leave pet food outside unattended.
- Put garbage in sealed containers.

CONTROL

Structural

Live traps

To remove a squirrel from a roof or attic, you must determine where they enter. Baited cage traps may be used to capture the animals coming and going from their access holes. Peanut butter, shelled pecans or walnuts are good baits. Live trapping should be aimed at minimizing stress, as squirrels can die of shock when trapped. They should be incorporated into a wooden nest box or be completely covered so that the inside is dark and protected from weather. Traps should be checked two or three times a day, especially at dusk, so that animals aren't left overnight.

Bird feeders

- Place bird feeders atop of metal poles and a squirrel guard baffle underneath.
- If you must hang the feeder on a tree, place the feeder as far out on the branch as possible and a use a wire instead of a chain to hang it, as the wire is more slick, and baffle the feeder, or use a narrow tube feeder that squirrels won't be able to reach from the tree trunk.
- Spray Teflon® on poles as a good temporary measure.
- Install porcupine wire around the pole of a feeder, taking care not to place it where squirrels will fall. They are unable to find firm footing in the spines and can't climb the pole.
- Construct a closed cage with chicken wire (or any similar mesh wire with two-inch holes) around the feeder
- Mix cayenne pepper with Vaseline and apply to the feeder pole as a repellent.

Gardens

- Cage entire plants that squirrels are finding tasty.
- To prevent squirrels from digging in flower pots or small gardens, use hardware cloth, cut to fit around the stem of the plant and extended to the edges of the pot or garden just below the soil. Place small rocks near the edge of the pot or garden to hold it in place.
- Mix seeds with black pepper before planting, at a ratio of one teaspoon per pound of seed, as a squirrel deterrent.

TERMITE MANAGEMENT

IDENTIFICATION/HABITAT

	Dampwood	Drywood	Subterranean
Hometowns	Pacific coast, from Baja CA north to British Colombia, and in parts of ID, MT, western NV and western OR, most often along the coast, and the cold, dry, high elevations of the Sierra Nevada, Coast Range, Cascade and Rocky Mtns	From NC, across the southern border of the U.S., along the CA Coast as far north as the San Francisco Bay area, and in HI	Found throughout the United States
Personal Statistics	**Reproductives** Can exceed one inch in length, including wings; Cream to dark brown **Workers** About ½ inch long; White to cream. **Soldiers** About ¾ inch long; Head and jaws make a third of their length; Large, reddish brown to blackish head; Cream body	**Reproductives** About ½ inch long; Fully developed wings; Usually dark brown **Workers** Less than ½ inch long. Wingless; White. **Soldiers** About 5/16 inch long; Massive brown head; Large mandibles; Light colored bodies	**Reproductives** About 3/8 inch long, including wings; Long, light grey, translucent wings; Dark brown to black cylindrical bodies **Workers** Up to ½ inch long; White to grey. **Soldiers** About ¼ inch long; Enlarged, cream head; Large mandibles; Greyish-white body
Fecal Facts	Pellets are about 1 mm (1/25 inch) long; Slightly hexagonal; Expelled in sawdust-like piles from exits in galleries.	Tiny, hard, straw-colored pellets; Six distinct concave surfaces	No fecal pellets
Housing Preferences	Damp, decaying wood	Dry sites	Ground dwelling in moist sites
Bad Habits	Thrive in high-moisture wood; Soil-wood contact often leads to infestation; Activities can expand into sound wood and relatively dry wood; Tend to work from the foundation to the roof rafters.	Live entirely in wood. Begin new colonies in pre-existing openings in wood; Excavate small nesting area or gallery and plug the hole for protection from predators.	Colony is located in the ground; Forage for food in aboveground wood; Travel from underground tunnels to food sources in mud tubes; Prefer moist wood and cork; Most active in summer; Winged reproductives fly off to create new colonies in late spring.

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PREVENTION

Structural

Pre-construction

Site Preparation

- Remove all tree roots and stumps from the building site before starting construction.
- Remove grade stakes, form boards and wood scraps from soil before filling and backfilling.
- Do not bury wood in the backfill, under porches, steps or patios.

Foundation

- Slab-on-ground foundations are most susceptible to termite attack. Termites can enter wood by going over the edge of the slab, through expansion joints, openings around plumbing and cracks in the slab. Monolithic type slab is the best, followed by a supported slab, and then floating types.
- A poured, reinforced, crack-free concrete foundation hinders the passage of termites. Termites can go through a crack as small as 1/32 inch.
- Hollow-block or brick foundations should be capped with a minimum of 4 inches of concrete.
- Make certain there are 12 inches of clean concrete foundation between soil surface and structural wood.
- Sand grain barriers are effective. When grains are 1.6 to 2.5 mm, they are too heavy for termites to move out of the way, and the spaces separating the grains are too small to fit between. A 4" layer of sand is required under a concrete floor slab. With crawl spaces, there should be a 4-inch layer of sand around the interior of the foundation wall and around any piers. All possible paths between the soil and the wood framing must have a sand barrier.
- Termimesh™, a finely woven, stainless steel mesh designed as a barrier for under and around foundations, prevents termites from entering a building. *Pest Control* magazine (February 1999) reported that after five years of testing, stainless steel mesh remained 100 percent successful as a barrier to subterranean termites.
- Steel termite shields prevent termites from entering through the interior cracks of masonry walls or foundation blocks. A good metal shield placed on top of foundation and piers may prevent mud tubes from reaching the wood above them, but will more likely cause termites to build around the shield, making their mud tubes easily detected and destroyed.

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Ventilation

- Create ventilated spaces between the ground and any wood structure.
- Cover earthen crawl space floors with a vapor barrier – sheets of polyethylene (available at any home supply store) that cover all exposed areas, keeping moisture and dampness at the ground level instead of infiltrating the crawl space. The plastic is usually covered with sand or fine gravel to protect it from punctures when it is walked upon. It should be sealed around the perimeter to the foundation wall, and at any seams, with long-lasting caulking or mastic.
- If you vent your crawl space, be sure it has two, if not four, ventilation openings within 10 feet of the corners to provide for cross-ventilation. Vents should be opened in the winter and closed in the summer to prevent moisture problems.

Building

- Build with termite-resistant materials, such as concrete and steel.
- Unfinished wood can be protected from termite attack by treatment with boric acid (Bora-Care®, Jecta®). Applied as a water solution by dipping or spraying the wood, it will penetrate deep into the wood, and act as an alternative to the afore mentioned barriers.
- Do not place basement partitions, posts, or stair stringers until the concrete floor has been poured.
- No wood should ever extend into or through concrete.
- Avoid using styrofoam insulation in the soil adjacent to foundation and basement.

Soil Grading

- The finished grade outside the building should slope away from the foundation for good water drainage. In the final grading, allow a minimum of 4--6 inches of clearance between the top of the ground and the bottom edge of the veneer.

Post-construction

- Fill cracks or voids in concrete or masonry with expanding grout or high-grade caulk, and also caulk around sinks and bathtubs.
- Install fan-powered kitchen and bathroom vents to control moisture.
- Eliminate dampness - remove or fix sources of water, such as leaky pipes and plumbing, leaky irrigation systems, and improper guttering and siding, and repair leaky roofs.
- Replace rotten or damaged wood using naturally insect resistant wood.
- Cover exposed wood with paint or sealant.
- Screen windows, doors and vents with 20-grade mesh screen.

Both

- Ensure good drainage away from the house – point downspouts or gutters away from the structure, into storm sewers or a drainage well.

Cultural

- Eliminate all earth-to-wood contact, including mulch, scrap wood, lumber, fence posts, trellises, shrubbery, tree branches or stumps, and firewood that come in contact with the house.
- Trim or eliminate shrubbery that blocks airflow through foundation vents.
- Move any soil or compost piled up next to the house at least 10 feet away from the structure.
- Keep planter boxes built on the ground at least four inches from the house.

INSPECTION

Dampwood

Dampwood termites hide themselves to prevent moisture loss, and are hard to spot. The most obvious sign of termite activity is swarms coming from the building, usually on warm evenings in late summer or fall, especially after rain.

- Look around and under the structure for damp or damaged wood with holes or tunnels in it and wood that sounds hollow or soft when tapped.
- Use a screwdriver or pick to pry into suspicious areas and open up holes.
- Look for piles of sawdust and dead insects and any conditions that may be promoting moisture or wood decay.

Drywood

Drywood termites can be difficult to detect, as they live almost entirely inside wood.

- Look for discarded wings left behind after swarming, fecal pellets, and blistered, hollow-sounding wood.
- They are distinguishable from ants because ants have elbowed antennae, a narrow "waist" and a dark spot on their wings.

Subterranean

- Look for piles or droppings of sawdust, dead or alive termites, swarms (usually in the spring, beginning in mid-March and through May, after a rain has softened the ground), discarded wings, mud tubes or mounds, and wood damage.

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- Use screwdriver or pick to detect damaged wood.
- Regularly inspected solid wood or corked hollow stakes in turf can alert you to activity that may require attention.

All

- Specially trained dogs can sniff and listen for termite infestations, even in hard to reach areas.
- Fiber-optic scopes can provide views or hard to inspect areas, such as behind drywall and paneling.

CONTROL

DAMPWOOD AND DRYWOOD

Non-toxic

- **Removal of the infested wood or furniture** is the quickest and easiest way to handle a localized infestation. Small pieces of wood containing live termites can be soaked in soapy water to kill the insects. Larger pieces can be taken to a landfill or natural area where the decomposing abilities of the termites are helpful.

DRYWOOD

NON-TOXIC

- **Cold treatment** is a temperature-altering system that utilizes liquid nitrogen to eliminate drywood termites. It is reported to have a 95-99 percent elimination rate and is a good method for inaccessible areas (*Journal Econ. Entomol.*, 89(4): 922-934). Small holes are drilled into the walls and liquid nitrogen is injected into the infested area, lowering the temperature enough to kill the termite colonies. Small items infested with drywood termites can be placed in a freezer or outside for several days during cold weather.

- The **Electrogun™** is a device that kills drywood termites using a high frequency, high voltage and low amperage electrical current. It should not be used if infestations are widespread, and is not effective next to metal, concrete, or ground because the current is diverted from the termites. It kills approximately 95 percent of the termites when used properly.

- **Microwaves** are effective as a spot treatment or localized infestations. An unshielded microwave device is used to raise the infested area's temperature

to 190°, killing the termites. Your microwave oven will not be effective for small, infested items.

LEAST-TOXIC

- **Desiccating dusts**, such as diatomaceous earth and silica aerogel can be used during new construction or in existing buildings to prevent drywood termite infestations. Choose a desiccating dust that it is not combined with a pyrethrin. Diatomaceous earth must be garden/food grade, as swimming pool grade is associated with lung disease and ineffective at controlling insects. Desiccating dusts abrade the outer shell of the termites, causing them to dry out and die. They are also inorganic and not subject to decomposition, and should protect wood against termites for the life of the building. Avoid breathing in desiccating dusts, as they can cause lung irritation, and always wear a mask and goggles when applying.

SUBTERRANEAN

NON-TOXIC

- **Dig out the colony and break open the mud tubes**. Openings will allow natural predators of the termites, especially ants, to invade the colony and kill them. Ants compete with termites and may kill them and limit their foraging.

LEAST-TOXIC

- **Baiting Systems** are the newest innovation in subterranean termite control. They control termites in and around a structure using carefully placed bait stations, which contain a toxicant that is brought back to the colony by the foraging termites. Baits greatly limit the amount of a pesticide used as opposed to the traditional liquid termiticide soil barrier method of control, and decrease chances of exposure to the chemical because the baits are well contained. They are, however, still poisons and should be used with utmost care and only as a last resort.

  Stations are installed below the ground in the yard, positioned within the structure in the vicinity of active termite mud tubes or feeding sites, or above ground in known areas of termite activity, typically in the direct path of active termite tunnels after the mud tubes have been broken.

  Baits consist of cardboard, paper or other acceptable termite food that will compete with the surrounding tree roots, stumps, wood piles and structural wood. The toxicant must be slow acting to enhance the transmission of the

poison to other termites, including those not feeding on the bait, and to avoid the build up of dead or sick termites in the vicinity of the bait station, which would cause other termites to avoid the area.

The least-toxic bait station is Termitrol™, containing boric acid. More toxic baits include Firstline™ (sulfluramid), Terminate™ (sulfluramid), Sentricon™ (hexaflumuron), Exterra™ (diflubenzuron), and Subterfuge™ (hydramethylnon).

ALL

NON-TOXIC

- The termiticide **Bio-Blast™** contains *Metarhizium anisoplae*, a common soil-borne fungus, as the active ingredient. The spores from the fungus penetrate and begin to grow inside the termite within 4 to 14 days. Bio-Blast™ powder is mixed with water and injected into active termite galleries.

- **Nematodes,** mixed in a water solution and injected into the wood or soil near termite colonies, seek out the termites and destroy them. They will live up to two years. Applicators have reported effectiveness ranging from 50 to 95 percent.

- **Heat treatment** consists of covering the structure and raising the temperature above the temperature at which most termites cannot survive. Heat will only be effective for subterranean termites if they are above ground. The process consists of tenting the structure and setting up propane burners that blow hot air through ducts to the infected area inside. When the core of the wood reaches 130° for 35 minutes, most termites are killed. A Berkeley study found that 90-99 percent of termites were killed by heat treatment (*Journal Econ. Entomol.*, 89(4): 922-934).

LEAST-TOXIC

- **Boric Acid** is an effective, least-toxic termiticide. It acts as an effective bait at concentrations of 0.15 percent, an antifeedant at concentrations greater than 0.25 percent, and kills by direct contact with concentrations greater than 0.5 percent.

  Structural lumber used in new house construction and treated with boric acid is termite resistant; older houses may be made more termite resistant with remedial treatment with borate sprays or by injection into wood already in place. Termites in their galleries are killed when they come in contact with

injected borates, and then groom themselves, ingesting the poison. Boric acid kills by inhibiting digestive enzymes and causing termites to starve to death.

Bora-Care® and Jecta® are effective products for pre-and post-construction treatments to prevent and control termite infestations; Tim-bor® is an effect post-construction treatment.

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THRIP MANAGEMENT

IDENTIFICATION

There are over 6,000 species of thrips in the world. They are in their own taxonomic order, Thysanoptera, which is divided into two suborders Terebrantia, which make a slit in the surface of a plant's epidermis and insert their eggs into the plant tissue, and Tubulifera, which lay their eggs on plant surfaces, in cracks and in other protected areas.

They are 1/5-inch long or less, and feed by scraping the surface of the plant tissue and sucking up the juices that are set free. They take the form of barely visible, slightly animated straight lines when clustered along the veins on the undersides of leaves. Their fecal spots and the damage they cause by scraping the leaf surface are usually more visible than the thrips themselves.

Thrips are a primary vector for impatiens necrotic spot virus, a damaging virus, and the sole vectors for tomato spotted wilt virus.

Terebrantia tend to be pest thrips, such as greenhouse and onion thrips, while Tubulifera are an important common predator of mites, small aphids and other thrips. Terebrantia adult female thrips insert several hundred eggs into the tissues of flowers, leaves or stems. The eggs hatch within days in warm weather, or weeks to months in colder weather. They become wingless larvae (nymphs) that feed on plant sap. After two or more nymphal stages, many thrips drop to the soil, where they remain through the prepupal and pupal stages. Emerging adults fly to the plant and repeat the cycle. Only the two larval stages and the adults are active feeders; the prepupal and pupal thrips are rest stages.

Development from egg to adult takes about two weeks in warm weather and a month in cooler weather. Adults have two pairs of fringed wings, which are normally held back over and parallel to the body. Males are rare in most species. They can apparently rely almost entirely on parthenogenetic reproduction, in which females produce young without mating.

Heavily infested leaves appear brownish or silver and dried rather than wilted. The growing points of the plant may become distorted. Some species, like the greenhouse thrip, leave copious amounts of their soot-like fecal matter on the leaves, which may be more noticeable than the insects themselves.

HABITAT

Thrips preferentially feed on flowers and leaves, and cause little to no damage to fruit itself.

PREVENTION

Because many pest thrips descend to the ground to spend their resting pupal period, the species can be controlled if they are prevented from finding suitable pupation sites or are attacked in the soil during pupation by nematodes or pathogens.

Cultural

- Ensure plants receive adequate soil moisture, and regularly mist plants with water or deliver all irrigation from overhead.
- Periodically flood earthen greenhouse floors to drown pupating thrips.
- Use aluminum foil mulch around the base of plants to disorient thrips and prevent those thrips that pupate in the soil from finding suitable pupation sites. Plastic sheets, roofing paper, newspaper, or brown kraft paper can also be placed over soil or under benches and interfere with pupation.
- If you weed, pull weeds inside and near the outside of the greenhouse, bag them, and dispose of them outside the greenhouse.
- Maintain a 10 to 30 foot vegetation-free zone around the outside perimeter of the greenhouse, especially near vents and openings. A heavy-duty geotextile weed barrier (DeWitt Sunbelt® Weed Barrier) covered with bark mulch or gravel can provide an effective vegetation-free zone.
- Clean up all plant debris from previous crops and dispose of infected plants or any infested growth.
- Temporarily quarantine and inspect all plants upon arrival from other greenhouses and regularly monitor stock plants used for propagation.
- Greenhouse workers should avoid wearing yellow clothing, since many pests are attracted to this color and may hitch a ride from one greenhouse to the next.

Biological

- Avoid general use pesticides, which will kill natural predators of thrips.
- Place potted garlic plants ever 30 square feet of bench area to repel thrips.

INSPECTION

Hot-pink or blue sticky traps that attract thrips are available for use in greenhouses. The traps are available as lengths of thin, sticky ribbon used to monitor large greenhouse crops and as cards that can be attached to stakes and

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placed in individual plant pots or hung above groups of plants. When using ribbon traps in greenhouses, they should be hung vertically so that the top of the trap is two feet above plants, with the bottom of the plastic strip an inch or two above the plant canopy, as most thrips fly within a two-foot zone above the plants.

Scouting should also be done once a week to monitor the efficacy of control measures. A hand lens is a good tool to detect live thrips and signs of thrips activity, such as black feces and silvery, flecked areas on leaves. Lightly blowing blossoms and growing points aids in visual inspection, as it causes thrips to become mobile.

Certain plants are appealing to thrips, and can be used as "biological indicators" to detect the presence of thrips in greenhouses. Majestic, Blue Magic, and Calypso petunias are recognized as thrips indicators because they will exhibit viral symptoms of tomato spotted wilt virus, a virus transmitted by thrips, within just a few days after feeding. Symptoms on petunias include a distinct brown rim at the feeding site within three to four days after feeding, followed by a localized circular lesion in about one week. Flowers should be removed from the petunias to discourage adult thrips from feeding on the flowers instead of the foliage, because viral lesions will not show up on the flowers. To use petunias as indicator plants:

- Place sticky cards throughout your operation to detect where thrips are located and monitor their numbers.
- Place indicator plants among crops at bench or floor level – one plant every 20 to 30 feet seems to work well.
- Place incoming plant material with indicator plants and isolate for at least three to four days to allow thrips scars to develop and show viral lesions.

CONTROL

NON-TOXIC

- **Moisture.** Dry plants are most likely to suffer thrips attacks. Where thrips are a problem indoors, adequate moisture may be the first and most important step in control. High moisture helps kill thrips by spreading fungi to which they are very susceptible and by drowning the thrips when they attempt to pupate near the soil surface.

- **Maintain diverse vegetation around outdoor lath structures and greenhouses.** Plant-eating thrips have many natural enemies in undisturbed areas, and destroying weeds actually can cause the thrips to migrate onto cultivated plants and removes their natural enemies.

- **Mulches** have been used to control thrips on a small scale on high-cash crops outdoors. Aluminum foil mulches closely surrounding the stems of plants disorient thrips by creating a bright, highly reflective vegetation or surface beneath them instead of the usual duller, less reflective vegetation or earth.

- Two **predatory mites**, *Neoseiulus (=Amblyseius) mackenziei* and *Amblyseius cucumeris* can control thrips, easily be mass produced, and can coexist with other predators released in the same settings to control other pests. They consume one to ten young thrips per day and have a 30-day life span. They can survive on pollen and spider mites if they temporarily run out of thrips to eat. The mites are most often applied in small piles at the base of plants, or in paper bags. Usually a small hole is made in the bag and mites slowly move out. The mites prey primarily on the egg and larval stages, and so you will be likely to see adult thrips on the leaves long after the overall pest population has been substantially reduced. New foliage should show progressively less damage. Control should be noticeable two to three months after the first release. Making periodic releases, particularly in the driest, hottest times of the year, should keep thrip populations in check. A 1:2 ration of predators to prey should be maintained.

- One of the most voracious predators of thrips are **lacewing larvae.** They prey upon some of the more difficult-to-control thrip species that do not descend to the ground and become vulnerable to other control tactics. Thrips are not lacewings' first choice of food, and so you must pay special attention to where and how frequently you release them. They are best purchased as larvae in packages where each larva has its own six-sided compartment because they attack their own kind as readily as they prey upon pests. Transfer the larvae to each plant with a fine-pointed paintbrush, using water to wet the brush, or by holding the individual hex cell over the plant and tapping it with a pencil so the larva drops to the foliage. One larva per plant is usually enough.

- Thrips, since many pupate in the soil, are potentially vulnerable to insect-eating **nematodes.** It is possible to control some thrips species indoors using commercially reared nematodes by adding them to the fertilizer water of affected plants, and periodically watering the plants with the mixture. Nematodes kill the immature thrips and pupating larvae while they are in the plant-growing medium. The nematodes are sold under the name Guardian™.

- **Damsel bugs and pirate bugs** are also natural predators of thrips that can offer control outdoors or be brought inside to aid in thrip control in greenhouses and sun porches. The minute pirate bug (*Orius tristicolor*) and western damsel bug (*Nabis alternatus*) have been observed to prey on common

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indoor thrips. They are large enough to be easily visible to the gardener and slow-moving enough to catch, but have a remarkable ability to cling to whatever they're on. Invert a wide-mouthed glass jar over the bug as it walks over the leaves, and quickly bring the jar lid up underneath it. Use the pressure of the lid of the jar rim to tear off the small amount of foliage on which the bug is sitting, trapping the bug in the jar. Cap the jar. Indoors, shake the bugs out onto the foliage of affected plants. Pirate bugs can consume 5-20 thrips per day, and can survive on pollen in the absence of prey. They are the only predator that attack thrips in tight places like flower buds.

- The fungus ***B. bassiana*** has shown effective use against thrips. The pathogenic fungus enters the insect's cuticle, invading the pest's body and stopping it from feeding. Products include BotaniGard™ and Naturalis-O™.

LEAST TOXIC

- **Diatomaceous earth** is made from the ground skeletons of small, fossilized animals. When thrips come in contact with it, its sharp edges lacerate their exoskeletons, causing the insects to die from dehydration. Choose a desiccating dust that it is not combined with a pyrethrin. Diatomaceous earth must be garden/food grade, as swimming pool grade is associated with lung disease and ineffective at controlling insects. Avoid breathing in desiccating dusts, as they can cause lung irritation, and always wear a mask and goggles when applying.

- **Horticultural oils and insecticidal soaps** can be used to provide temporary relief from thrips while awaiting the arrival of predators. Both of these materials are of relatively low toxicity, but will kill a wide variety of insects and mites, including those that are beneficial.

TICK MANAGEMENT

IDENTIFICATION

There are over 650 hard tick species in 15 genera and 155 soft tick species in five genera. Hard ticks (ixodids) occupy many more habitats and parasitize a greater number of animals in a wider variety of environments than soft ticks (argasids). The life cycle of all ticks consists of egg, larva, nymph, and adult. The larva only has three pairs of lets, but molts and becomes a nymph with the four pairs of legs that it will retain throughout the rest of its life. Hard ticks molt once between the nymphal stage and maturity, while soft ticks may molt as many as five times before they become adults and are capable of being fertilized and laying eggs.

Hard Ticks

Hard ticks are the most readily recognized by most people. Because their mouthparts extend forward of the body and are visible when the tick is viewed from the back, they appear tapered at the head end. They also have a noticeable shield on their backs, which does not occur on soft ticks. The shield covers most of the body on the males and is small on the females. The male does not swell greatly after taking a blood meal, but the female is capable of great expansion. After engorging on a blood host, the female lays a very large batch of eggs, usually between 1,000 and 4,000, but as many as 12,000, and then dies. After the six-legged larval stage, ixodids have one nymphal stage, and then molt into the sexually mature adult stage.

Because hard ticks feed for a long time, management programs involving ticks that transmit diseases place great emphasis on tick removal. A hard tick may wander around a fresh host for several hours before settling down. While feeding, they secrete salivary cement that hardens gradually so they become more difficult to dislodge the longer they remain attached.

Tick species differ from each other in their response to environmental conditions, longevity, reproductive powers, preferred habitats, ability to transmit various pathogens, and their choice of hosts. Hard ticks generally lack the ability of soft ticks to withstand dehydration and starvation.

In order to find hosts, hard ticks "quest" – the larvae crawl up grasses or other vegetation and wait for hosts to appear. The third pair of legs clings to the grass, and the other legs are waved about, ready to grasp any suitable host that passes by. The height a tick can climb is important for selecting the size of the host from

which it will feed. Ticks also are sensitive to carbon dioxide and other chemical clues emanating from the host, are attracted to body heat, can detect the right skin texture or fur on which to crawl, and can identify the taste of host tissues and blood.

There are four categories of tick/host relations: one-host; two-host; three-host; and many-host ticks. The designations refer to the number of times a tick feeds during its lifetime – a one-host tick feeds once, etc… The number of different species that a particular tick can feed on is more important than the number of times it feeds during its lifetime, however. If a particular tick species can obtain suitable nourishment from many different species of animals, it is less likely that the tick population in any given area can be reduced by removing its hosts.

Common Pestiferous Hard Ticks

Cattle Ticks

Cattle ticks are one-host ticks. Lives of one-host ticks are divided into two phases – a parasitic phase in which the tick lives attached to the host and a non-parasitic phase in which the tick lays its eggs on the ground and the larvae hatch. The total life cycle of the tick, from egg to egg, is about 60 days. Tick larvae have been known to survive during cool weather for as long as 167 days without feeding. Cattle ticks can infest horses, donkeys, sheep, goats and other animals, and heavily infested animals become weakened because of loss of blood. Because the larvae can take up water directly from a humid atmosphere prior to dawn, can drink dew, and can travel short distances on hosts that they do not feed upon, such as birds, they are not easily eliminated from a pasture or range area. Nonetheless, cattle ticks have been successfully eradicated in the southwestern United States.

The Brown Dog Tick

One of the most widely distributed ticks on the planet, it feeds primarily on dogs, but also may feed on rats and mice. It can become a problem indoors, and favors a drier and warmer environment than the American dog tick. The brown dog tick and American dog tick are the most likely tick species to be found on pets.

The adult female is uniform brown in color and about 1/8-inch long. She is fertilized by the male while on the host, and, after engorging, drops off and searches for a sheltered location in which to lay her small brown eggs. Engorged females are sometimes seen crawling on walls or around baseboards and cracks in the house looking for a place to deposit their eggs. She may lay 1,000 to 5,000 eggs, depending on the temperature and availability of food, and survives only one or two days after laying her eggs. Eggs hatch in 20 to 60 days. The larval ticks climb walls and attach to a passing dog or available host. If no host is

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available, they can survive up to eight months without a blood meal. This stage feeds for three to six days on a dog, falls off, and molts into the eight-legged nymph stage, which will feed and molt again before becoming an adult. After each blood meal, the tick climbs up to a sheltered hiding spot while preparing to molt. After three or four additional days and another blood meal, mating occurs and egg laying begins. The full life cycle takes 24 months, and adults can live up to 18 months without feeding.

The brown dog tick can cause irritation, anemia, and paralysis in dogs. It can transmit the causal organism of canine piroplasmosis (a lethal blood disease) and malignant jaundice in dogs, and is a vector of Rocky Mountain spotted fever of humans in parts of Mexico.

The American Dog Tick

This species is common on dogs, but will feed on horses and cattle. It is a two-host tick, with the adult tick most common on dogs. Adults and immatures are also found on raccoons, possums, skinks, the gray squirrel, and humans. It is the species in the eastern U.S. most likely to be found on humans, and is also an efficient vector or Rocky Mountain spotted fever and tularemia (a bacterial disease of rodents and rabbits), which can be fatal in humans. This species is a common cause of tick paralysis in humans, dogs, and wildlife species.

Adult females are ¼-inch long and dark brown with a mottled white shield on their backs. Similar to the brown dog tick, the female lays large masses of eggs, all stages can live for long periods without blood meals, and unengorged adult ticks have been shown to go for more than 500 days without feeding if they cannot find a suitable host. The late summer peak of the American dog tick arises from eggs laid in the spring and summer.

The Pacific Coast Tick

This is another human-biting tick with a broad host range. It has been collected in California from approximately 25 species of small- to large-sized mammals or vegetation and is a serious pest of cattle throughout the year. It is a three-host tick whose life cycle can be completed on rodents and large mammals in less than three months.

Adults have pale ornamental markings on the shield-like plate on their upper back. It is a small tick, with an unfed female measuring about 1/8-inch long. They are infested naturally with Colorado Tick fever virus, spotted fever group rickettsiae, the agents producing Q-fever and tularemia, and the Lyme disease spirochete. It has been implicated a s a cause of tick paralysis in cattle, deer and ponies in California.

The Rocky Mountain Wood Tick

Adults feed mainly on large mammals such as horses, cattle, sheep, deer, bears, and coyotes; larvae and nymphs on small mammals such as rabbits, ground squirrels, pine squirrels, woodchucks, and chipmunks; and all three stages may feed on intermediate-sized mammals such as jack rabbits and porcupines. Adults look similar to the American dog tick, but are paler in color. This is a three-host tick.

Adults mate on the animal host and the female drops off to lay her eggs. The larvae engorge on smaller mammals, then drop to the ground to molt. The nymph also feeds on one of the smaller mammals and then drops to the ground, molts, and becomes an adult. Depending on the number of rodent hosts, it may overwinter as an adult or a hibernating nymph. They are very resistant to starvation - unfed, newly hatched larvae and young nymphs can live about a year without food, and adults can starve considerably longer. It may take one to three years to complete its life cycle.

The Rocky Mountain wood tick is a potent vector of Rocky Mountain spotted fever, can transmit Colorado tick fever, Q fever, and tularemia. Its saliva can cause paralysis in humans, cattle, dogs, cats and other domestic animals, and wildlife. Usually only the adult bites humans; June and July are the season of greatest danger, but August may also be included in higher elevations and mountains.

The Northern Deer Tick

This tick is the primary vector of Lyme disease in the northeast and midwest areas of the U.S. It is found on 12 mammalian species and 18 bird species, but derives its name from its close association with the white-tailed deer.

Northern deer ticks are extremely small – nymphs are no larger than a period and adults are about the size of a sesame seed. They live about two years and feed three times. Adult ticks mate in the fall on the host animal, usually a white-tailed deer, the adult male dies, and the female drops from the host to lay about 2,500 eggs in the soil in the spring, and dies. Larvae emerge about a month later and attach themselves to a host, usually a white-footed mouse, in the late summer or early fall and take a blood meal. After feeding, the larvae drop off the host (often in the mouse burrow), molt, and enter the nymph stage the following spring. Nymphs feed once in early summer. The white-footed mouse is the main reservoir of the Lyme disease spirochete and is again the preferred host. Many nymphs spend most of heir time in mouse burrows. Nymphs molt into adults in the fall. Adults feed once in fall or winter and die after mating and egg deposition.

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Aside from Lyme disease, the Northern deer tick can also transmit the malaria-like disease babesiosis.

Symptoms of Lyme disease can vary from person to person, but in most cases a bump that looks like a bulls eye develops along with a possible rash at the site of the bite or elsewhere on the body. The bump will be red on light skin and look like a bruise on dark skin. , and will usually occur within 30 days of a bite. In that time, the person may also develop flu-like symptoms: fatigue, chills, headache, muscle and joint aches, and a low fever. In about 25% of cases no rash or bump will develop at all. Anyone bitten by a tick in an area with a high rate of Lyme disease should contact their doctor.

The Western Black-legged Tick

Immature stages of the Western black-legged tick, a three-host tick, feed on small rodents, rabbits, lizards, birds, and occasionally on large mammals. Adults mount grasses and brushy vegetation to await a passing host, and feed on more than 80 species of vertebrates, particularly large mammals, including deer, dogs, and humans. In California, adult ticks are most active between November and May, while larvae and nymphs are most commonly found from March through June.

The adult, unfed female tick is red-brown with black legs and measures about 1/10-inch in length. The adult is smaller and all brownish black; both are teardrop shaped. Mating occurs on the host animal, the female drops off the host, lays several thousand eggs, and dies. Larvae feed on a host, drop off to molt into the nymph stage, feed again on a host, drop off and molt to adults, and feed once more.

Bites may produce painful sores that are slow to heal. It is the primary vector of Lyme disease in the western U.S. and also transmits tularemia in humans, tick paralysis in dogs, and rickettsiae of the spotted fever group in other animals.

The Eastern Black-legged Tick

A small, three-host tick that feeds on humans, this tick is a vector of Lyme disease and has a painful bite.

Adults are active in the winter and spring, and the young in the spring and summer. In the winter, adults mate on large mammals. Larvae and nymphs are found on small mammals and birds.

Lone Star Ticks

The lone star tick gets its name from the white spot on the back of the adult female, and is sometimes called the "speckback" for this same reason. It readily

bites humans in all stages, is a vector of Rocky Mountain spotted fever, can cause tularemia, has itchy, painful bites, and has saliva that may cause tick paralysis.

This tick is a three-host tick that feeds on a wide variety of hosts. The larvae feed easily on rodents, but can also be found on larger animals such as dogs and humans. The female adult may feed and engorge on the host for six to 13 days. They overwinter in ground trash, under stones or in soil. Mating occurs on the host, the female drops to the ground and lays as many as 9,000 eggs in a favorable site, such as under leaf mold. The larvae that hatch from a single egg mass may remain together on low-growing vegetation, waiting for a suitable host to pass by. A person or animal brushing against this aggregate of larvae may receive hundreds to thousands of bites at the same time. Larvae that do not reach the nymph or adult stage until late summer hibernate and complete their life cycle the following spring.

The Gulf Coast Tick

The Gulf Coast tick is a serious problem on cattle, often simply referred to as the 'ear tick,' but is also a frequent biter of humans and dogs. It is a three-host tick. The larvae and nymphs attack ground-inhabiting birds such as meadowlarks, quail, sparrows, and grasshoppers, and small mammals. The adults attack a wide range of domestic and wild animals.

As adults, this species tends to confine its feeding to the middle and outer areas of the ears of its hosts, inflicting severe damage because of the long mouthparts and comparatively large blood meal. Periods of adult tick activity range from early spring through September and vary from one locality to another.

Soft Ticks

Soft ticks do not have a shield-like plate on the upper surface, and may appear to have a blunt head-end because their mouthparts are entirely or partially hidden when viewed from above. After the larval stage of development, there may be as many as eight nymphal stages. The female will feed several times during her life and will lay several batches of eggs. Male and female soft ticks resemble each other, with leathery, wrinkled skin and an indented design particular to each species. Most soft ticks feed rapidly, often at night, and then leave promptly. As an adaptation to hosts such as birds, bats, or desert vertebrates that shift habitations, these ticks can drastically reduce their metabolic rate and undergo a torpor that permits survival under actual- or near-starvation conditions, often for many years. For this reason, once a soft tick species is found in an area, it generally must be accepted as a permanent component of the ecosystem. They are also important vectors of disease in much of the world.

Common Pestiferous Soft Ticks

The Spinose Ear Tick

This one-host tick has an unusual life cycle. The adult mates and lays eggs in cracks and crevices under the bark of trees or in fence posts or wooden animal shelters. The six-legged larvae hatches, finds a host, goes deep into the ear, attaches and feeds. It undergoes a remarkable change in shape, resembling a bladder-like grub – elongate at the anterior end where the mouthparts are located. After molting, the first stage nymph re-attaches, feeds, and molts again. The second stage nymph re-attaches, feeds until it is engorged, and leaves its host to molt into maturity. It finds a mate and repeats the life cycle. Young ticks may spend from five weeks to several months in the ear of the host.

Fowl Ticks

This tick parasitizes chickens, pigeons, and wild birds in much of the world. It is pale yellow and oval before it has fed, and a little, reddish globule after feeding. It is about ¼-inch long after feeding. They usually attach under the wings of birds and are easily seen. This tick likes to squeeze itself into tight places where it can feel the substrate pressing against both sides of their body. They feed at night and will travel some distance from their hiding places to find a host. After feeding, they drop off and return to some crevice, remaining inactive during the day.

Larvae may remain attached as long as five days, and are usually the stage at which fowl ticks are noticed. Adult fowl ticks feed for only short periods of time and go without food for long stretches – the female can fast for up to ten weeks.

There is no way to completely rid an area of ticks. Conventional pesticides have been ineffective and create risks for people and the environment. For a pesticide to work, it must come in with or be consumed by the pest. Ticks do not eat vegetation and are likely to spend most of their lives in sheltered areas, like mouse burrows, where pesticides will not come in contact with them.

Some techniques have been effective in significantly reducing the population of ticks in a given area. It is important to understand the life cycle of the ticks and their relationship to other animals.

HABITAT

Brown dog ticks, in southern states, is found outdoors in kennels, small animal hospitals, sheds and outbuildings, and in yards, as well as indoors. In northern states, it is rarely found outdoors, and is common inside homes with pet dogs. Searches for this tick should be centered on window moldings and trim, picture

moldings along walls, and similar cracks and crevices in areas where the dog may sleep or rest indoors, on the porch, in and around sheds, wooden fences, etc... The brown dog tick has also been found in lawns in Florida – an indication of its preference for hotter and drier conditions.

American dog ticks do not become established indoors, but may occasionally be found indoors if they happen to drop off the dog. It is most common east of the Rocky Mountain and is now also found along the Pacific Coast. Nymphs usually engorge on field mice, and are found in fields and meadows where these rodents live.

Pacific Coast ticks are abundant from mid to late winter, when the weather becomes warm and dry. It is found in the coastal mountains and Sierra foothills of California.

The Rocky Mountain Wood Tick is widely distributed in North America from Western Canada, through the Rocky Mountain states to New Mexico, Arizona, and California. It is especially prevalent where the predominant vegetation is brushy, with good protection for small mammalian hosts of the larvae and nymphs, and with sufficient forage to attract large hosts required by the adults.

The Northern deer tick is found primarily in the northeastern U.S., although it is also found in areas of the Midwest where deer herds are abundant.

Western black-legged ticks are found in California, Idaho, Nevada, Oregon, Washington, Utah, and in British Columbia, and on the western slope of the Sierra Nevada mountain range. It typically prefers humid coastal areas, and can be found in urban and rural areas year round.

The Eastern black-legged tick is common along the east coast as far north as Massachusetts, and in south central and southeastern U.S. It tends to congregate along paths and roadways.

Lone star ticks, despite their name, are distributed as far north as Montana, Minnesota and Maine, and can be found throughout the midwest, northeast, and the entire south. It cannot stand exposure to the sun and is encountered primarily in shady areas in wooded pastures or brush in shady areas, but not in low wetlands.

Gulf Coast ticks are found in all Gulf and Atlantic Coast states, from Delaware south, plus quite a few adjoining states as far north as Kansas and as west as California. It is expanding its range through the transport of infested cattle. Adults live in grasslands and prairies, sheltered by a medium-height overstory.

Soft ticks live in deserts, under dry conditions in wet climates, hiding in crevices or burrowing into loose soil, or climbing the walls of caves and stables inhabited by horses.

The Spinose ear tick is widely distributed in western Canada and western and southwestern U.S.

Fowl ticks are found worldwide.

PREVENTION

Cultural

- Do not let pets go outside, especially in the summer.
- If pets go outside, keep them out of known tick-infested areas.
- Confine pets to certain areas for sleeping, and wash bedding regularly to remove ticks.
- Vacuum the walls and surfaces around the dogs' sleeping quarters regularly. Destroy the contents of the vacuum by burning , heating in a plastic bag in the sun, or freezing.
- Reduce tick populations by discouraging mice.
    - Remove piles of leaves or other debris that may provide shelter for mice.
    - Clean around bushes and under trees.
    - Store wood piles away from the home and elevate them.
    - Keep metal trash containers with tightly closed lids.
- Wear light-colored clothing that covers your body, especially your legs. It is easiest to spot ticks on light clothing, and they can be removed before they bite.
- Tuck your pants into your socks.
- Wear a hat.
- Use only unscented deodorant, soap and shampoo. Packers Tar Soap seems to keep ticks from biting once they have been picked up.
- Use an herbal repellant that is effective against ticks.
- Use steel wool to fill large cracks in structures, then repair them with wood, plaster or other permanent material.
- Seal small cracks, including those around repaired areas, between wall and baseboard, etc... with a good quality silicone seal caulk and one or more layers of paint.
- Control humidity in the turf – alter the vegetation to admit sun down to the soil level and increase air flow to dry areas out and make them less hospitable to ticks. Prune trees to encourage sunlight to penetrate the ground. Keep grasses mowed. Water turf deeply and infrequently, allowing the surface to dry out between irrigations. Improve drainage by grading, dethatching and aerating the lawn.

BEST COPY AVAILABLE

- Keep vegetation mowed below ankle heights to remove an adequate vantage point for attachment. A mowed strip four to six feet wide along pathways is recommended.

- Modify vegetation to reduce the attractiveness of a specific area to the hosts of ticks at various times of the year when the different stages of ticks are active.
- Manage rodents around buildings and recreation areas.
- Control deer in the area, using ground covers and shrubs that are distasteful to deer, repellent, and fencing.

INSPECTION

Brown dog ticks are often found in the ears and between the toes of dogs. Larvae and nymphs are most commonly found in the long hair at the back of the neck.

- Regularly check your pet for ticks using a flea/tick comb, available at most pet stores. Check your pet each time they have been outdoors, or at least twice a week. Pay special attention to the areas behind the ears and between toes. Be careful not to break off any embedded ticks, and remove any found ticks in the same way described for humans. Clean the wound with soap and water and apply antiseptic. The tick can be killed by placing it in soapy water or alcohol.
- Rub a masking-tape lint roller over the trunk and heads of small cats or dogs to capture ticks.
- Frequently check the areas where your pet sleeps.
- While in a tick-infested area, check yourself once per hour for crawling or newly attached ticks. Pay special attention to the pantleg between the ankle and knee. Pick off crawling ticks and drop them into a small pill or plastic film canister, where they will die within 24 to 48 hours.
- Check your entire body for ticks if you have been in an area where ticks are present, soliciting help or using a mirror for hard-to-see areas. Pay special attention to behind the ears, the back of the neck, between toes, and the groin.
- Take a shower to wash off any ticks that have not yet become embedded.
- Check anything you were carrying and wash clothing in soapy water to kill any unnoticed ticks.

CONTROL

NON-TOXIC

- If you find an embedded tick, **remove it** carefully. Protect your hands with gloves or a tissue. Use blunt, curved tweezers, not your bare fingers, and

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exert pressure on the head of the tick and gently pulling the tick straight out very slowly. Do not twist and do not crush the tick. The body fluids can cause infection if exposed to even unbroken skin. Do not kill the tick while still embedded. Coating with petroleum jelly will block its breathing apparatus and force it to withdraw, usually within 30 minutes. Kill the tick in soapy water or alcohol, clean the wound with antiseptic, and monitor carefully for any signs of infection.

- Use a **tick drag** to reduce tick populations in an area. The idea is to drag a piece of light-colored flannel cloth across vegetation where ticks may be waiting for a host. Ticks will attach themselves to the cloth and then can be killed by placing the cloth in soapy water. It is best to drag any areas where you or your pets may be walking – along a path or where your pet rests. Use caution when doing a tick drag, as the person doing the drag is at risk for being bitten by a tick.

- **Carbon dioxide traps** also effectively reduce tick populations, as ticks are attracted by the carbon dioxide emitted by their hosts. Dry ice is placed in a trap where it will emit carbon dioxide and attract ticks.

  Place 2 lbs. Dry ice in a bucket and punch ¾ inch holes near the bottom. Place the bucket on a piece of plywood or flannel material with a strip of masking tape around the edge, sticky side up. The tape can be secured with tacks or staples. The trap will last about 3 hours. Check the trap frequently, removing any ticks found with tweezers. After the dry ice is gone, check again for any ticks, and soak the cloth in soapy water to kill any ticks found.

LEAST-TOXIC

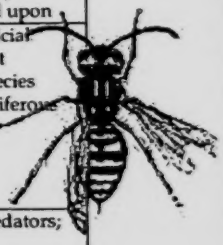
- **Silica aerogel and diatomaceous earth** have a drying and abrasive effect on insects. They can be gently blown into cracks and crevices where ticks hide before cracks are caulked shut permanently, or can be applied where caulking is not feasible. . Choose a desiccating dust that it is not combined with a pyrethrin. Diatomaceous earth must be garden/food grade, as swimming pool grade is associated with lung disease and ineffective at controlling insects. Avoid breathing in desiccating dusts, as they can cause lung irritation, and always wear a mask and goggles when applying.

WASP AND YELLOWJACKET MANAGEMENT

IDENTIFICATION

Wasps are beneficial insects that eat harmful insects and pollinate flowers. The most common species are the solitary and paper wasps, yellow jackets, and hornets.

Species	Description	Habits	Nests	Feeding Behavior
Solitary wasps	Thin- or thick-waisted	Visit flowers and other vegetation; relatively docile	In mud or in holes in the ground	Predators; provision nests with prey for young to feed upon
Yellowjackets and Hornets	Stout, colorful; mostly black and yellow or black and white	Rapid fliers; aggressive individuals capable of inflicting multiple stings; social in large colonies, which they defend vigorously	Multi-layered, papery nests, mostly in ground, although some aerial or in structures; nests have an outer papery covering called an "envelope"	Mostly beneficial predators, but scavenger species becomes pestiferous
Paper (umbrella) wasps	Long bodies with thin waists, long dangling legs	Social; search vegetation for prey, visit flowers for nectar; not very aggressive	Single-layered, papery nests without an envelope; attached to fences, eaves, boards, branches; shaped like an umbrella	Beneficial predators; feed prey to developing young in nest



HABITAT

Wasps and yellowjackets are attracted to protein foods in the early months of summer, and sweet foods and drinks at the end of their life cycle. When a protein or sugar food source is generated by humans and readily available, it may be discovered early in the season by the queen, and the extra nutrients may be used to increase the size of her colony beyond what she could sustain on naturally available foods.

Nests tend to be underground, in hollow trees, or in the eaves, attics, and inside wall cavities of buildings.

PREVENTION

Structural

- Inspect and repair the exterior surfaces of the structure, looking for cracks, splintered or rotten wood, holes in stucco or the foundation, unscreened vents, loose shingles, open plumbing cuts into the basement, and loose fascia

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boards. Duct tape, copper mesh, spackle, caulk, and cement patch are effective exclusion materials.
- Cover attic and crawl space vents with fine mesh insect screen.

Cultural
- Avoid wearing scents, such as perfumes, hair spray, suntan lotions, cosmetics, deodorants and shaving lotions.
- Don't wear brightly colored, patterned clothing, but do wear shoes.
- Don't squash wasps or yellow jackets – it releases a chemical alarm that signals other wasps and yellowjackets in the area to attack.
- Use a lid and straw with soft drinks and juices; carry sugary or meat snacks in closed containers.
- Feed pets indoors or in a screened enclosure.
- Clean recyclables before storing them.
- Keep garbage cans clean and tightly covered, or seal all food garbage in plastic bags. Equip outdoor garbage cans with removable domed tops that have vertical, spring-loaded swinging doors or with spring-fitted lids. Periodically clean the lids of food wastes. Empty the cans frequently, especially during the most severe period of infestation, and monitor them daily, disposing of misplaced materials.
- Empty and clean dumpsters frequently. Dumpster lids should seal tightly and be kept closed when not in use. The area around the dumpster should be monitored daily, and all misplaced materials should be disposed of properly.

Biological
- Skunks, raccoons and badgers prey upon yellowjacket nests for the honey in the larval chambers.

INSPECTION

If there is a chronic problem with yellowjackets; inspect the area methodically to locate the nests. Nests can be found in the ground, under eaves and in wall voids of buildings. Ground nests are frequently located under shrubs, logs, piles of rocks, and other protected sites. Entrance holes sometimes have bare earth around them. Nest openings in the ground or in buildings can be recognized by observing the wasps entering and leaving.

Inspect monthly to ensure that nests do not become large enough to be problematic.

CONTROL

NON-TOXIC

- If the wasp of yellowjacket lands on you, stay calm and do not move quickly. If you can't sit still until it flies off on its own, gently brush it off with a piece of paper using slow, deliberate movements.

- If the insect enters your vehicle and is moving, slowly and deliberately guide it out with a piece of paper or invert a cup over it, slip a piece of stiff paper under the open end, trapping the insect inside, carry it outside, and free it, pointing the opening away from you as you slowly pull the paper away.

- **Drip honey over the nest entrances** at night when no one will be around the nests. In the morning, a helpful skunk or raccoon may have enjoyed a good meal and taken care of your nest for you.

- **Traps** can be used to reduce wasp and yellowjacket populations and monitor the effectiveness of ongoing control programs. Baits, placed in the saucer or plate at the bottom of the trap (dog food, ham, fish and meat scraps early in the season, sugar syrups, spoiled fruit and jelly late in the season), attract the insects. Once flying in, they can't escape. Commercially available fly traps are effective for wasp and yellowjacket control, with the appropriate bait.

- Another method of destruction is **physically removing the nest**. However, any mass disturbance to a nest will trigger a mass attack, so hiring a professional is highly recommended if this is the route you choose. If you are daring, you will need special protective clothing to ensure your safety.

- **Vacuuming** can be effective, for nests in wall voids and underground. You should first consult a professional experienced in handling stinging insects. Use a lightweight, powerful vacuum with a removable bag that can be stuffed closed with cotton or a rag while the machine is running. Vacuuming underground nests is a two-person job, with one person operating the vacuum and the other excavating the nest with a trowel. First check for auxiliary nest openings in a 40- to 50-foot area around the main opening, and fill any found with soil. Wear protective clothing. The vacuum should be held about 3 to 4 inches from the entrance of the nest so that the wasps are sucked in as they fly from the nest. Before the vacuum bag is full, vacuum up two tablespoons of cornstarch to incapacitate the wasps. Once the nest is empty, with no more wasps entering or leaving, dig out the underground nest structure. With the vacuum still running, open the canister and tape over the bag opening with duct tape. With the motor off, take out the bag and

place it in a cardboard box. Seal the box and place it in a freezer at least overnight. Aerial nests and ground nest fragments that contain living larvae, should be placed in thick plastic bags and put in a freezer at least overnight.

LEAST-TOXIC

- **Silica aerogel** is a desiccating dust that can be used to destroy underground nests or a nest in a wall void. The dust abrades the outer waxy coating on insects, causing them to dry up and die. Choose a desiccating dust that it is not combined with a pyrethrin. **Avoid breathing in desiccating dusts, as they can cause lung irritation, and always wear a mask and goggles when applying.**

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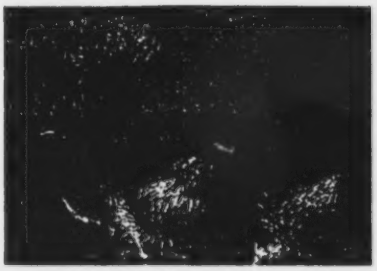
LEAST-TOXIC CONTROL OF WEEDS

IDENTIFICATION/HABITAT



School lawns often cover several acres and serve many roles – athletic fields, community recreation areas, and outdoor classrooms. Heavy use of lawns and athletic fields cause stress that predisposes them to attack by weeds, pest insects and pathogens.

The key to a healthy school lawn is good cultural practices that optimize the growth of grasses and minimize conditions favorable to pests, pathogens and weeds.

When pest numbers exceed tolerance levels, there are a wide variety of strategies and tactics that are available. The first approach is always addressing conditions causing stress to lawns. Presence of weeds is a sign of a lawn undergoing stress, which is a common occurrence on school lawns and athletic fields. Stresses may include levels of use unsuited to the grass species that has been planted, compacted soils, improper mowing heights, too much or too little irrigation or fertilization, accumulation of thatch, and uneven grading.

Pest problems can be reduced or eliminated by relieving stress. For example, the weed yellow nutsedge grows best in waterlogged soils, indicating a faulty or broken irrigation valve or low spot in the lawn.

PREVENTION

Cultural

The most vigorous lawn growth occurs in loose, loamy soils teeming with beneficial microorganisms, insects, worms, and other organisms. Thewse organisms play a critical role in transforming thatch and grass clippings into humus. Humus slowly releases nutrients and buffers grass roots from extremes of drought or other stresses. Soil organisms also play an important role in biological pest control. Certain beneficial microorganisms protect lawn roots from attack by soil pathogens or insects. Humus in the soil is the key to a healthy soil ecosystem. To improve poor soils:

- Insure that organic matter is routinely replenished by leaving grass clippings to decompose;
- Fertilize or topdress with organic matter, such as sludge and composted manure;
- Select blends of grass species tolerant to occurring conditions and resistant to local pest problems;

- Reduce soil compaction through aeration, topdressing and rotation of mower patterns.
    - Aeration loosens your soil, allowing air, water and nutrients to reach the roots of your grass. Lawn grasses also root better in aerated soil, and oxygen will help the grass grow. It involves removing plugs of grass to improve air exchange and water penetration into the soil. Heavily used turf should be aerated two to four times per year. Aerating can provide a seedbed for problem weeds, so time aeration operations to avoid periods when heavy seeders, such as crabgrass, are germinating or setting seed.
    - Follow aeration with a topdressing of composted sludge along with seeds of the desired lawn grass. Drag the lawn with a piece of cyclone fencing to break up cores of soil left by the aerator and to fill holes with the topdressing equipment.
    - Rotate the point of mower entry onto the lawn from week to week to minimize soil compaction.
- Mow high. Most temperate grasses used on school lawns, such as tall fescues, perennial ryes, and bluegrasses, can be mowed at two and a half to three inches without sacrificing vigor or function. The taller the grasses can be kept and the denser the canopy, the greater the interception for available sunlight. Shaded soil makes it less likely for weed seeds to germinate. Also, adjust the mowing frequency to changes in the growing season. The right interval between mowings allows grasses to recover from the previous cut and enter the second growth phase when new blades are produced at the growing points. This keeps lawns growing in a tight, dense manner that discourages weeds.
- Irrigate properly. The length of time needed to adequately water lawns is determined by the time it takes to wet it to the depth of the root system. Most lawn grass roots extend four to six inches into the soil, but irrigation schedules need to be tailored to individual lawns and adjusted for seasonal changes. Infrequent, deep irrigation is preferred to shallow watering, which promotes shallow rooting. Use a soil probe or a pointed tool like a screwdriver to determine when the soil is wet four to six inches below the soil and to determine how long to leave sprinklers on at each irrigation.
- Keep thatch to a minimum – less than ¾ inch. Thatch is the accumulation of dead but undecomposed roots and stems that collect in a layer at the soil surface. It prevents water and nutrients from adequately penetrating the soil. Water puddles on thatch, enhancing the habitat for disease organisms. Regular aeration keeps thatch a tan acceptable level, and the use of organic fertilizers promotes thatch decomposition. Excessive layers of thatch can be removed with de-thatching rakes or with power de-thatchers available from equipment rental companies. Lawns thinned by de-thatching should be re-seeded to out-compete weeds that attempt to occupy the openings.

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- Only apply the levels of nutrients needed. Excessive nitrogen fertilizer produces weak grass blades with thin cell walls that are susceptible to pest attack. A soil test should be obtained before planning annual fertilizing programs. Only the levels of nutrients needed should be applied, and split applications – one in the spring and one in the fall – should be used rather than one heavy application in the spring. Use slow-release fertilizer to prolong the availability of nutrients throughout the growing season. Organic fertilizers are preferable because they provide organic matter to support soil microorganisms and improve soil health. Fertilizer may actually help suppress weeds as well by stimulating grass growth early on so it is able to crowd out weeds.
- Maintain proper soil pH. Test the soil and adjust the pH if necessary. Low pH means high acid content – add lime to the grass to raise the pH and lower the acidity to 6.7-7 for most grass varieties. High pH means high alkalinity – add sulphur to lower the pH, taking care not to add too much and burn the lawn. A hint that your pH may need adjusting is a dandelion infestation. Dandelions love soil with a pH of 7.5, while grass loves a pH of 6.7-7. Nothing will successfully conquer your dandelion problem until you correct your lawn's pH.
- Seal cracks in sidewalks and stone walkways.

Biological

- Plant well-adapted, pest-resistant grass varieties. You can find out which grass is most suitable to your climate from your local cooperative extension. A mix of two or more grass varieties is preferable. Overseeding, or planting additional seeds in already established turf, has been shown to reduce weed problems in some cases.

INSPECTION

Monitoring is essential to a good lawn IPM program, no matter the pest. Make regular inspections of the lawn to gather and record site-specific information on which to base pest control decisions. Monitoring will enable you to identify the weeds, pests and pathogens, determine if any treatment is needed and, if so, where, when and what kind of treatment, and evaluate and fine tune treatments as the pest management program continues throughout the season.

Become familiar with the common pests and weeds of the area. Learn how to recognize them and their life cycles. Map all areas of the lawn, noting locations of existing problems or conditions that could produce pest problems, like a broken sprinkler or bare spot. Identify the grasses in each area and record the maintenance history of the turf and current horticultural practices. Give each major section of the lawn an identifying number and prepare a monitoring form for recording on-going maintenance activities and information about pests and their management in each section of lawn.

Prepare a complete list of lawn maintenance equipment so that you know what is needed and has to be worked into the budget process. Evaluate the state of repair of the equipment. Are the mower blades sharp? Can the mowing height be easily adjusted? Does the equipment have flotation tires to reduce soil compaction?

Determine a tolerance level – how many weeds or pests can be tolerated before action needs to be taken. Tolerance levels in the front of the school, which is in constant view of the public, may be lower than that of the playing fields and behind school buildings. Tolerance levels will also be different depending on the pest or pathogen present and the potential for damage.

To measure weed levels:

- At the beginning and end of the season, establish three parallel transect lines along the length of the field, using the center of the field and two imaginary lines on either side. These three transects will give sufficient data to indicate a percentage of weed cover in the total turf area.
- Calculate the number of paces you will be walking between samples.
    - Measure the length of the pace of the person doing the transect. Slowly walk a known length, count the number of paces it takes to cover the distance, and divide. This figure represents the average length of the pace.
    - Divide the length of the field by the length of the pace to establish the number of paces it takes to walk the transect.
    - Divide the number of paces by the number of samples to be recorded. For example, 180 paces divided by 20 samples would mean a sample should be taken every 9th pace along the transect.
- Stretch lines of string along the three transect lines, laying the string directly on the ground.
- Create a monitoring form that lists transects A, B and C with the number of samples that you will be taking. Make boxes for each sample labled "yes," "no," and "bare," and a place to notate the type of weed.
- Beginning at one end of the first transect, walk the calculated number of paces, and stop and look at a three by three foot area immediately in front of your toe. If the area contains a weed, mark the yes box and note what type of weed it is. If more than 25% of the area is bar, mark the bare box, and continue pacing the transect line. Repeat along the other two lines.
- To calculate the average percentage of weeds, total the number of boxes marked 'yes' in each column and multiply by 100. Divide that number by the total number of boxes in all columns. The resulting figure represents average percent weed cover in the turf. Do the same calculation with the boxes representing bare ground. This will indicate percent area that will become weedy if not seeded to grass.

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- By collecting data from the transects at the beginning and end of each season, the turf manager can spot emerging problem areas. If several boxes in succession are marked 'yes,' indicating weed presence, a closer look at this area on the transect is warranted. Usually such clumping of weed growth indicates exceptionally heavy wear on the turf, although structural problems such as severely compacted soil, a broken irrigation line, inoperative sprinkler head, or scalping of the turf due to uneven grade may be indicated.

Monitoring the turf from season to season will indicate if weed populations are rising, falling or remaining stable. This will indicate whether or not current turf management practices are keeping weeds at or below the agreed-upon tolerance level. If weed populations are rising, changes in management practices are necessary.

CONTROL

NON-TOXIC

- **Pull weeds by hand.** It is the oldest and most effective method for weed control, especially before young weeds have set seed. Plants are best removed when the ground is moist. With perennials, vegetative parts must be removed from the garden to prevent resprouting.

- **Simple hand tools** can be used to uproot plants. A standard hoe, hula hoe, trowel, dandelion knife, and electric flail mower can handle many weed problems. Others include the spiked-tooth harrow, the disk harrow, the rod weeder, the rotary hoe, and shovel cultivators. A rototiller can be used for larger areas.

  A hoe can be used to scrape broadleaf annual weeds off at the soil surface. They are destroyed as they dry in the sun. Annual weedy grasses should be chopped out just below the soil surface. Cultivating when moist, then allowing the soil to dry will increase the control. Larger weeds can be mowed or flailed with a weed-whip such as the Weedeater™. A Weed Wrench™ is effective for removing brushy weeds without greatly disturbing the soil and encouraging other weeds to germinate. A Weed Whacker™ a type of flail mower, and also an effective tool for cutting down weeds. To avoid spreading the weed, do not move seed infested soil from one area to another.

- **Flaming** is an inexpensive and not labor intensive way to control weeds in sidewalks, gardens and lawns. The object of flaming is to burst plant cells, causing loss of fluids and thermal denaturation of proteins and DNA.

Disrupting the photosynthetic apparatus in this way causes the weed to wilt and die. Overheating and charring the plant may cause a stimulation of growth from the remaining roots, requiring another flaming of the sprout. For optimum heating, hold the wand about an inch or more above the plants and move it slowly back and forth. To treat large areas, wave the wand back and forth over the area in a scythe-like movement. After flaming, the weed may not wilt and die for several hours. Dead weeds can be removed and composted or incinerated to ashes on the spot, leaving a mineral source fr further plantings.

Flaming works best on broadleaf annual weeds, but can also kill grasses and perennial weeds in some circumstances. Most weeds are susceptible when they are an early growth stage. They should be flamed when they are one or two inches high. Most grasses are especially resistant to flaming because they form a protective sheath that shields the growing tip from the flame. This means that flaming can be safely used to remove broadleaf weeds without damaging a lawn.

- **Hot water** can be applied as a spot treatment for weeds in turf or cracks. It melts away the waxy coating on leaves, or breaks down the plants' cellular structure. Treated plants are unable to retain moisture, and dehydrate within a few hours to a few days. It kills new and mature plants. Machines are available for this method of weed control. Hot water is a broad-spectrum biocide that kills beneficial soil microorganisms as well as insect pests and weeds, so care should be taken if employing this method of weed control.

- **Smothering** can be used when there are large expanses of weeds. Irrigate, cover the area with a layer of black plastic, anchor the plastic with stones or bricks and leave it in place over the weeds for four to six weeks. This should kill even the toughest perennials. If aesthetics are an issue, cover the plastic with decorative bark mulch while the smothering is underway.

- **Use goats!** Goats prefer weeds to grasses. They have very narrow, triangular mouths that pick, nibble and chew very quickly. The shape of their mouths and how they chew crushes most weed seeds as they eat. Timing is very important, and when to graze will depend on your particular weed problem. Goats love Canada thistle, cheat grass, common candy, common mullein, dalmation toad flax, dandelions, dandy brome, Indian tobacco, knapweed, larkspur, leafy spurge, loco weed, musk thistle, oxide daisy, plumeless thistle, poison hemlock, purple loofstrife, scotch thistle, snapweed, sweet clover, yellow star thistle, and yucca.

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LEAST-TOXIC

- **Vinegar.** When applied to weed foliage, the acid in the vinegar acts as a contact herbicide that kills the plants, but does not persist in the soil or cause water or other pollution. A five-percent concentration of vinegar, similar to that found in household vinegar, killed top growth on Canada thistle within a day and a 20 percent concentration of vinegar worked in two hours. The weaker solution was effective on young weeds up to two weeks old; older and more mature plants required a 15 to 20 percent concentration. Anyone applying the stronger concentration should wear protective gear and take precautions because it is very acidic.

- **Corn gluten meal** is a less-toxic pre-emergent herbicide. It is the protein fraction of corn and inhibits foot formation on a wide variety of broadleaf and grassy weeds during germination. It is 60 percent protein and 10 percent protein by weight. It is most effective when mixed into soil before seeds are planted. Turfgrass management systems are restricted to surface applications, and with these conditions good control is expected for annual bluegrass, black nightshade, buckhorn plantain, catchweed bedstraw, common lambsquarters, curly dock, dandelion, giant foxtail, orchardgrass, purslane, redroot pigweed, and smooth crabgrass. Competition from the mature grasses in turfgrass may increase the degree of weed control and allow lower application rates than needed in greenhouse pot tests. Applications must be properly timed to be effective. No control can be expected after a weed has already rooted. After the corn gluten meal is added to the soil, it is slowly inactivated by soil microorganisms making early applications less effective. The best time to apply is three to five weeks before weed germination.

- **Herbicidal soaps** are effective for annual, post emergent weed control. They only destroy the exposed foliage and do not translocate to kill perennial roots, but will kill perennial foliage. Scythe™ is an herbicide formulated from the fatty acid pelargonic acid, which acts as a germination inhibitor. It is a fast acting, broad-spectrum herbicides that has no soil activity. It can be used in seedbeds, next to shrubs and ornamentals, is non-volatile, and will not harm plants unless sprayed directly on them.

Section Three

School IPM Resources

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I. MODEL SCHOOL PEST MANAGEMENT POLICY

_____ School District

Board of Education Policy No. _____

SECTION 1. Preamble.

(a) The maintenance of a safe, clean, healthy environment for students and staff is essential to learning and is a goal of the school district.
(b) The use of toxic chemicals to control pests and weeds may itself threaten staff and students' health and ability to learn.
(c) Similar programs in other school districts and institutions around the country have shown that Integrated Pest Management (IPM) is a viable, cost-effective approach to controlling pests.

SECTION 2. Policy Goals.

(a) To prevent unnecessary exposure of children to chemical pesticides and provide the healthiest learning environment, playgrounds, and playfields possible.
(b) To promote safer alternatives to chemical pesticides while preventing economic and health damage caused by pests.
(c) To ensure that clear and accurate notification concerning the use of pesticides in schools be made available so that measures may be taken to prevent and address pest problems effectively without endangering children or adults.
(d) To implement the use of integrated pest management techniques to reduce the need for reliance on chemical pesticides.

SECTION 3. Definitions.

(a) "Anti-microbial pesticide", a pesticide that is used for the control of microbial pests, including, but not limited to, viruses, bacteria, algae and protozoa, and is intended to disinfect, sanitize, reduce or mitigate growth or development of microbiological organisms. Anti-microbial pesticides shall not include any fungicide or pesticide used on plants, turf or other vegetation or for ornamental uses.

(b) "Contact person" means an individual knowledgeable about integrated pest management systems and designated by a local educational agency of a school district.

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(c) "Crack and crevice treatment" means the application of small quantities of a pesticide in a building into openings such as those commonly found at expansion joints, between levels of construction, and between equipment and floors.

(d) "Emergency" means an urgent need to mitigate or eliminate a pest that threatens the health or safety of a student or staff member.

(e) "Integrated pest management" means a managed pest control program that eliminates or mitigates economic and health damage caused by pests, minimizes the use of pesticides and the risk to human health and the environment associated with pesticide applications, and uses:

(a) integrated methods;
(b) site or pest inspections;
(c) pest population monitoring;
(d) an evaluation of the need for pest control; and,
(e) one or more pest control methods, including sanitation, structural repairs, mechanical and living biological controls, other non-chemical methods, and, if nontoxic options are unreasonable and have been exhausted, a least toxic pesticide.

(f) "Least toxic pesticide" means boric acid and disodium octoborate tetrahydrate; silica gels; diatomaceous earth; nonvolatile insect and rodent baits in tamper resistant containers or for crack and crevice treatment only; microbe-based insecticides; pesticides made with essential oils (not including synthetic pyrethroids) without toxic synergists; and materials for which the inert ingredients are nontoxic and disclosed. Least toxic pesticide does not include a pesticide that: is determined by the U.S. Environmental Protection Agency as a probable, likely, or known carcinogen or endocrine disruptor; is a mutagen, reproductive toxin, developmental neurotoxin, or immune system toxin; is classified by the U.S. Environmental Protection Agency as a toxicity I or II pesticide; is in the organophosphate or carbamate chemical family; or contains inert ingredients categorized as "List 1: Inerts of Toxicological Concern." Least toxic pesticide does not include any application of pesticide using a broadcast spray, dust, tenting, fogging, or baseboard spray application.

(g) "Pesticide" means any substance or mixture of substances, including herbicides and bait stations, intended for preventing, destroying, repelling, or mitigating any pest; use as a plant regulator, defoliants, or desiccant; or use as a spray adjuvant such as a wetting agent or adhesive. Pesticide does not include: an antimicrobial agent, such as a disinfectant, sanitizer, or deodorizer, used for cleaning purposes.

(h) "School" means any school for pre-kindergarten, kindergarten, elementary, or secondary school students in the school district or any pre-school/day care center receiving government funding for a Head Start program.

(i) "School grounds" means the area outside of the school buildings controlled, managed, or owned by the school or school district and includes a lawn, playground, sports field, and any other property or facility controlled, managed or owned by a school.

(j) "Space spraying" means application of a pesticide by discharge into the air throughout an inside area and includes the application of a pesticide using a broadcast spray, dust, tenting, fogging, or space spraying does not include crack and crevice treatment.

(k) "Staff member" means an employee of a school system and includes administrators, teachers, and other support personnel. Staff member does not include: a registered employee or applicator certified by the department; or a person assisting in the application of a pesticide.

(l) "Universal notification" means written notice by a school or school district to all parents and guardians of children attending the school, and staff members of the school.

Section 4. General.

(a) If, on the date of enactment of this policy, a school in this school district maintains an IPM system that meets the standards and criteria established by this policy, the school may continue to implement the system in a school or school district in accordance with this policy.
(b) The requirements of this policy apply to school buildings and school grounds of the school district.
(c) This policy shall apply to any person that applies a pesticide in a school or on a school ground, including a custodian, staff member, or commercial applicator.
(d) This policy shall apply to a school during the school year and during holidays and the summer months, if the school is in use, with notice provided to all staff members and the parents or guardians of the students that are using the school in an authorized manner.

Section 5. Local Educational Agency of a School District.

(a) A local educational agency of a school district shall develop and implement in its schools an integrated pest management system.
(b) School Integrated Pest Management Advisory Board.

(1) The local educational agency of a school district shall establish a School Integrated Pest Management Advisory Board to:
(A)establish uniform standards and criteria for developing integrated pest management systems and policies in schools; and
(B) develop standards for the use of least toxic pesticides in schools.
(2) The Board shall be composed of 12 members and include 1 representative from each of the following groups:
(A)parents;
(B) public health care professionals;
(C) medical professionals;
(D)state integrated pest manage system coordinator;
(E) independent integrated pest management specialists;
(F) environmental advocacy groups;
(G)children's health advocacy groups;
(H)trade organization for pest control operators;
(I) teachers and school staff members;
(J) school maintenance staff and school facility managers;
(K)school administrators; and,
(L) school board members.

(c) A local educational agency of a school district shall designate a contact person. The contact person shall:
(1) act as a contact for inquiries about the integrated pest management system;
(2) maintain material safety data sheets and labels for all pesticides which may be used inside or outside schools within the school district;
(3) maintain scheduling of all pesticide usage for schools in the school district;
(4) obtain periodic updates and training from state integrated pest management system experts;
(5) on request, make the school district and individual school's pest management and pesticide use data available to the public for review; and,
(6) present an annual report to the school board evaluating the progress of the integrated pest management program.

Section 6. Notice of Integrated Pest Management Plan.

(a) At the beginning of each school year, the local educational agency of a school district shall include a notice of the integrated pest management system of the school district in school calendars or other forms of universal notification.
(b) After the beginning of each school year, a local educational agency of a school district shall provide the notice required under this section to a newly employed staff member or the parent or guardian of a student newly enrolled during the school year.

(c) The notice shall include:
(1) a description of the integrated pest management system of the school district;
(2) a list of all pesticides, including any least toxic pesticide, that may be used in a school building or on a school ground as part of the integrated pest management system;
(3) the name, address, and telephone number of the contact person of the school district; and
(4) a statement that the contact person maintains the product label and material safety data sheet (MSDS) of each pesticide used by the school in buildings and on school grounds, that the label or MSDS is available for review by the public upon request, and that the contact person is available to parents, guardians, and staff members for information and comment.

Section 7. Pesticide Notification.

(a) Universal Notification.
(1) Not less than 72 hours before a pesticide, other than a least toxic pesticide, is applied in a school building or on school grounds, the school district shall provide to each parent and guardian of each student enrolled at the school and each staff of the school, notice that includes:
(A)the common name, trade name, and U.S. Environmental Protection Agency registration number of the pesticide;
(B) a description of the location of the application of the pesticide;
(C)a description of the date and time of application, except that, in the case of outdoor pesticide applications, each notice shall include three dates, in chronological order, that the outdoor pesticide applications may take place if the preceding date is canceled due to weather;
(D)the statement that "The Office of Pesticide Programs of the U.S. Environmental Protection Agency has stated: 'Where possible, persons who potentially are sensitive, such as pregnant woman and infants (less than 2 years old), should avoid any unnecessary pesticide exposure;'"
(E) a description of potential adverse effects of the pesticide based on the MSDS for the pesticide;
(F) a description of the reasons for the application of the pesticide;
(G)the name and telephone number of the contact person of the school district; and
(H)any additional warning information related to the pesticide.
(2) The school district may provide the notice required by subsection (a)(1) by:
(A)written notice sent home with the student and provided to the staff member;
(B) a telephone call;

(C) direct contact; or
(D) written notice mailed at least one week before the application.

(3) If the date of the application of the pesticide needs to be extended beyond the period required for notice under this section, the school district shall reissue the notice under this section for the new date of application.

(b) Posted Notification Signs.

(1) At least 72 hours before a pesticide, other than a least toxic pesticide, is used by a school, the school district shall post a sign that provides notice of the application of the pesticide:
(A) in a prominent place that is in or adjacent to the location to be treated; and
(B) at each entrance to the building or school ground to be treated.

(2) A sign shall be posted as required under subsection (b)(1) for the application of a pesticide shall:
(A) remain posted for at least 72 hours after the end of the treatment;
(B) be of uniform design with a symbol people who cannot read can easily understand; and,
(C) state the same information as that required for universal notification of the application under subsection (a)(1).

(3) Sign Dimensions.
(A) If an application is made on school grounds the dimensions of each sign shall be at least 16 inches by 20 inches.
(B) If an application is made in a school building, the dimensions of each sign shall be at least 8 ½ inches by 11 inches.

(4) In the case of outdoor pesticide applications, each sign shall include three dates, in chronological order, that the outdoor pesticide application may take place if the preceding date is cancelled due to weather.

Section 8. Emergency Pesticide Use.

(a) A school may apply a pesticide subject to section 9 in a school or on school grounds without complying with all the provisions of section 7 only if a pest problem is deemed an emergency by the School Integrated Pest Management Advisory Board.

(b) Not later than the earlier of the time that is 24 hours after a school applies a pesticide under this section or on the morning of the next school day, the school district shall provide universal notification to each parent, guardian, student, and staff member, notice of the application of the pesticide for emergency pest control that includes:

(1) the information required for a notice under section 7(a) of this policy;
(2) a description of the problem and the factors that qualified the problem as an emergency that threatened the health or safety of a student or staff member; and

(3) a description of the steps the school will take in the future to avoid an emergency application of a pesticide under this section.

(c) A school applying a pesticide under this section shall post a sign warning of the pesticide application at the time of the pesticide application and in accordance with section 7(b).

(d) If a school applies a pesticide under this section, the local educational agency of a school district shall modify the integrated pest management plan of the school district to minimize the future applications of pesticides under this section.

(e) A record of the emergency pesticide use, including the identification of the cause and the actions taken to address it, shall be maintained as a part of the records required under section 10 of this policy.

Section 9. School Pesticide Use.

(a) Pesticides shall not be made on a routine schedule (e.g. seasonal, monthly, or weekly).

(b) Pesticides shall only be used indoors when children are not on the property of a school, except for those pesticides defined as least toxic pesticides.

(c) Pesticides shall only be used on school grounds when children are not located in, on, or adjacent to the area of the pesticide application, except for those pesticides defined as least toxic pesticides. Pesticides, other than least toxic pesticides, shall not be used when a school or school ground is occupied or in use or will be during the 24 hour period beginning at the end of the treatment.

(d) A school may use a pesticide during a school year only if the use of the pesticide has been disclosed in the notice required under section 6 at the beginning of the school year.

(e) Pesticides that are in the organophosphate or carbamate family shall not be used in school buildings or on school grounds.

(f) Pesticides that contain inert ingredients appearing on U.S. Environmental Protection Agency's "List 1: Inerts of Toxicological Concern" shall not be applied in school buildings or on school grounds.

(g) Pesticides shall not be used for purely aesthetic purposes only.

(h) U.S. EPA acute toxicity category I and II pesticides shall not be used in school buildings or on school grounds.

(i) Pesticides identified by the State of California as chemicals known to the state of California to cause cancer, developmental or reproductive toxicity pursuant to California Safe Drinking Water Toxic Enforcement Act of 1986 (Proposition 65) shall not be used in school buildings or on school grounds.

(j) Pesticide applications made via fogging or space spraying shall not be used at schools.

Section 10. Record Keeping.

(a) A written or electronic record of all pesticide applications made at a school shall be maintained on site for a period of not less than seven years, and shall be made available to the public upon request.
(b) The record shall be completed on the day of the pesticide application, and shall include, but not limited to:

(1) the purpose for the desired application(s);
(2) the date and time of the application;
(3) the application area;
(4) the brand name and ingredients (active ingredients) of the pesticide product, the name of the pesticide manufacturer and the federal EPA registration number;
(5) quantity used of the pesticide and method of application;
(6) least toxic and non-chemical alternative methods or treatments available to accomplish the desired objectives and the reasons why the application of the proposed pesticide was chosen;
(7) the possible adverse effects to humans as stated on the label or MSDS; and,
(8) the name of the individual who applied the pesticide.

(c) The school district shall annually review its pest management program to evaluate how well its pest prevention and control objectives are being met, and to identify areas where improvement is needed. The report will be provided to school board members and made available to the public upon request. Summary information and notice of the annual report's availability will be provided along with the notice of the schools district's Integrated Pest Management Plan under section 6. The school district shall prepare a report containing the following information:

(1) quantities of each pesticide, including least toxic pesticides, applied during the year;
(2) target pest for each pesticide used;
(3) cost of the school district's pest management program for the year in review;
(4) number of emergency pesticide applications made during the year;
(5) non-chemical pest prevention and control measures used; and,
(6) pest management plan for the coming year.

Section 11. Meetings.

(a) Each local educational agency of a school district shall provide an opportunity, at least once each year, at a regularly scheduled meeting, for the contact person appointed under section 5(c) of this policy to receive and address

public comments regarding the system.
(b) The notice of the meeting shall be included in the universal notification required at the start of each school year under section 6 of this act.

Section 12. Buffer Zones.

The local educational agency and state pesticide lead agency are encouraged to:
(a) identify sources of pesticides that drift from treated land to school grounds of the educational agency; and
(b) take steps necessary to create an indoor and outdoor school environment that are protected from pesticides described in subsection (a)(1) which may include establishing buffer zones in a 2 mile radius around the school's property during commuting times and while students and school employees may be on school grounds.

Section 13. Antimicrobial Pesticides.

The department shall conduct a review of antimicrobial pesticides, as defined in section 2, to determine whether and to what extent they should be subject to the provisions of this chapter.

II. MODEL SCHOOL PEST MANAGEMENT CONTRACT

The following should be used as a starting point for schools contracting school pest management services out and should be edited to best fit the needs of the school district.

Procurement

a. Bidders for contracted pesticide application and pest monitoring must have staff entomologist with Bachelor's degree and be able to provide a copy of general liability insurance certificate.
b. All on-site contractor technicians must be certified applicators, over the age of 21 years old.
c. Contractor selection based on evaluation of technical proposal: bidders ranked by their IPM qualifications, not lowest bid

Scheduled Service

a. Technicians first respond to logged-in requests, then inspect general areas risk.
b. Each visit must include a thorough inspection of all areas covered by the contract to detect presence of pests and conditions conducive to pest infestations.
c. Pesticide applications are never on a pre-established scheduled.

Surveillance

a. Sticky trap placement localized and based on need.
b. Minimal surveillance record keeping: sticky traps used as diagnostic tool, not data collection tool.

Prevention

a. Emphasis on pest proofing and sanitation and make recommendations to school on how to avoid and reduce pest problems.
b. Contractors required to make specific recommendations on structural improvement and housekeeping.
c. Concessions: steam cleaning and pressure washing, caulking, proper waste disposal.
d. Custodial: Afternoon pickup, sanitation in mop closets and equipment rooms.
e. Structural Maintenance: restroom caulking, sealing utility access holes, plumping repair, door sweeps, weather stripping, vent and drain screens, etc.

Treatment

a. The least toxic pesticide may be chosen only after nontoxic strategies have

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been exhausted or are unavailable.

b. No fogging, space spraying.
c. Pesticides cannot be used for aesthetic reasons alone.
d. Emphasis on non-volatile baits, placed in areas inaccessible and out of reach of children.
e. No baiting with avicides.

Record Keeping

A written service report must be prepared each visit and include the following:

a. Name of School
b. Date of Visit
c. Time of Arrival and Departure
d. Name of technician
e. Brief description of service provided
f. Name, location, amounts and method of application of pesticides used
g. Actual pest sightings are reported in both the service report and Pest Sightings Log
h. Persons contacted
i. Conditions that are contributing to a current pest problem or that may be conducive to future infestations

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IV. IPM PRODUCT BUYING GUIDE

ANTS – INDOOR AND OUTDOOR

Non-toxic

Sticky Barriers
- Gardener's Supply Co. – 800-955-3370, www.vg.com/default.asp
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com
- Planet Natural – 800-289-6656, http://www.planetnatural.com/

Least-toxic

Botanical Sprays
- EcoSmart, 888-326-7233, http://www.ecopco.com/products.htm

Victor® Poison-Free® Ant or Ant and Roach Killer – mint oil or cedar oil
Concern Citrus Home Pest Control™ - orange peel
- Victor – 800-800-1819, www.victorpest.com

Boric Acid Baits/Products
Drax™ - boric acid bait
- Waterbury Companies, Inc. – 800-845-3495, www.cbproproducts.com
- Gardener's Supply Co. – 800-955-3370, www.vg.com/default.asp
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com

Niban® - boric acid granular bait
Nibor-D® - boric acid dust or liquid
- Nisus – 800-264-0870, www.nisuscorp.com/products.htm

Victor® Liquid Ant Killing System – boric acid and mint jelly
Victor® Boric Acid – 100% boric acid dust
- Victor – 800-800-1819, www.victorpest.com

Diatomaceous Earth/Silica Aerogel
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com

Safer ® Ant & Crawling Insect Killer – diatomaceous earth powder
Diatomaceous Earth Crawling Insect Killer – diatomaceous earth powder
- Victor – 800-800-1819, www.victorpest.com

ANTS – CARPENTER

Least-toxic

Boric Acid Products
Bora-Care® - boric acid wood treatment – liquid
Tim-bor® - boric acid wood treatment – dust, liquid or foam
Niban® or Niban FG® - boric acid granular bait
Nibor-D® - boric acid dust or liquid
- Nisus – 800-264-0870, www.nisuscorp.com/products.htm

ANTS – FIRE

Non-toxic

Nematodes
- Gulf Coast Bio – 800-524-1958, http://www.gulfcoastbio.com/

Least-toxic

Diatomaceous Earth/Silica Aerogel
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com

Safer ® Ant & Crawling Insect Killer – diatomaceous earth powder
Diatomaceous Earth Crawling Insect Killer – diatomaceous earth powder
- Victor – 800-800-1819, www.victorpest.com

Boric Acid Bait
Niban® - boric acid granular bait
- Nisus – 800-264-0870, www.nisuscorp.com/products.htm

D-limonene Products
Safer® Fire Ant Killer – d-limonene
- Victor – 800-800-1819, www.victorpest.com

COCKROACHES

Non-toxic

Sticky Traps
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com
- Gardens Alive – 812-537-8650, www.gardensalive.com

Victor® Insect Glue Board – sticky trap
- Victor – 800-800-1819, www.victorpest.com

Pheromone Trap
Victor® Roach Magnet – pheromone bait station
- Victor – 800-800-1819, www.victorpest.com

Least-toxic

Botanical Sprays
- EcoSmart, 888-326-7233, http://www.ecopco.com/products.htm

Victor® Poison-Free® Ant and Roach Killer – mint or cedar oil aerosol spray
Concern Citrus Home Pest Control™ - orange peel
- Victor – 800-800-1819, www.victorpest.com

Diatomaceous Earth Products
Safer ® Ant & Crawling Insect Killer – diatomaceous earth powder
Diatomaceous Earth Crawling Insect Killer – diatomaceous earth powder
- Victor – 800-800-1819, www.victorpest.com

Boric Acid Products
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com

Niban® or Niban FG® - boric acid granular bait
Nibor-D® - boric acid dust or liquid
- Nisus – 800-264-0870, www.nisuscorp.com/products.htm

Victor® Roach Killing Powder – 100% boric acid dust
- Victor – 800-800-1819, www.victorpest.com

FLEAS

Non-toxic

Flea Combs
- Gardens Alive – 812-537-8650, www.gardensalive.com

Sticky Light Traps
- Gardens Alive – 812-537-8650, www.gardensalive.com

Victor® Ultimate Flea Trap – light trap with attractant sticky glue disc
- Victor – 800-800-1819, www.victorpest.com

Nematodes
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com
- Planet Natural – 800-289-6656, http://www.planetnatural.com/
- Gardens Alive – 812-537-8650, www.gardensalive.com

Least-toxic

Diatomaceous Earth
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com

Safer ® Ant & Crawling Insect Killer – diatomaceous earth powder
Diatomaceous Earth Crawling Insect Killer – diatomaceous earth powder
- Victor – 800-800-1819, www.victorpest.com

Boric Acid Products
Victor® Boric Acid – 100% boric acid dust
- Victor – 800-800-1819, www.victorpest.com

Insecticidal Oil
- EcoSmart, 888-326-7233, http://www.ecopco.com/products.htm
- Gardens Alive – 812-537-8650, www.gardensalive.com

Concern Citrus Home Pest Control™ - orange peel
- Victor – 800-800-1819, www.victorpest.com

FLIES

Non-toxic

Traps
- Gardens Alive – 812-537-8650, www.gardensalive.com
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com

Victor® Disposable Fly Traps – attractant bait
Victor® Fly Ribbon – sticky paper
Victor® Indoor Fly Trap – design and colors attract flies
Victor® Electronic Fly Killer – ultraviolet light and glue board
- Victor – 800-800-1819, www.victorpest.com

Least-toxic

Botanical Sprays
- EcoSmart, 888-326-7233, http://www.ecopco.com/products.htm
- Planet Natural – 800-289-6656, http://www.planetnatural.com/

Victor® Poison-Free® Flying Insect Killer – mint oil
- Victor – 800-800-1819, www.victorpest.com

LICE

Non-toxic

Head Lice Comb
- National Pediculosis Association – 781-449-NITS, www.headlice.org

Least-toxic

Enzyme Treatments
- Not Nice to Lice – 909-372-9850, www.safe2use.com
- Lice-B-Gone – 877-730-2727, www.licebgone.com

MICE AND RATS

Non-toxic

Repellants
Victor® Sonic Pest Chaser – high-pitched frequency sound repellant
- Victor – 800-800-1819, www.victorpest.com

Live Traps
Havahart Traps
- Havahart - 800-800-1819, http://www.havahart.com/

Live Catch Mouse Traps – traps without killing
- Victor – 800-800-1819, www.victorpest.com

Snap and Glue Traps
- Victor – 800-800-1819, www.victorpest.com

Electricity
Victor® Rat Zapper - electricity
- Victor – 800-800-1819, www.victorpest.com

SQUIRRELS

Non-toxic

Live Traps
Havahart Traps
- Havahart - 800-800-1819, http://www.havahart.com/

Bird Feeder Guards
- Gardener's Supply Co. – 800-955-3370, www.vg.com/default.asp
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com
- Planet Natural – 800-289-6656, http://www.planetnatural.com/
- Gardens Alive – 812-537-8650, www.gardensalive.com

TERMITES

Non-toxic

Barriers
Termimesh™
- TX – 512-997-0066, HI – 808-843-1968, FL – 407-265-0665, http://www.termimesh.com/

Nematodes
- Hydro-Gardens – 888-693-0578, http://www.hydro-gardens.com/

Least-toxic

Silica Aerogel Products
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com

Boric Acid Products
Bora-Care® - boric acid wood treatment – liquid
Tim-bor® - boric acid wood treatment – dust, liquid or foam
Jecta® - boric acid gel
- Nisus – 800-264-0870, www.nisuscorp.com/products.htm

YELLOW JACKETS, WASPS AND HORNETS

Non-toxic

Traps
- Harmony Farm Supply – 707-823-9125, www.harmonyfarm.com
- Peaceful Valley Farm Supply – 888-784-1722, http://www.groworganic.com
- Gardens Alive – 812-537-8650, www.gardensalive.com

Victor® Yellow Jacket Traps with carbohydrate and protein bait
Safer® Disposable Yellow Jacket Trap with pheromone attractants
Victor® Yellow Jacket and Flying Insect Trap with carbohydrate and protein bait

Saver® Deluxe Yellow Jacket/Flying Insect trap with pheromone, carbohydrate and protein bait

- Victor – 800-800-1819, www.victorpest.com

Least-toxic

Botanical Sprays

- EcoSmart, 888-326-7233, http://www.ecopco.com/products.htm

Victor® Poison Free® Wasp and Hornet Killer – Mint oil, sodium lauryl sulfate, water, and carbon dioxide aerosol spray

- Victor – 800-800-1819, www.victorpest.com

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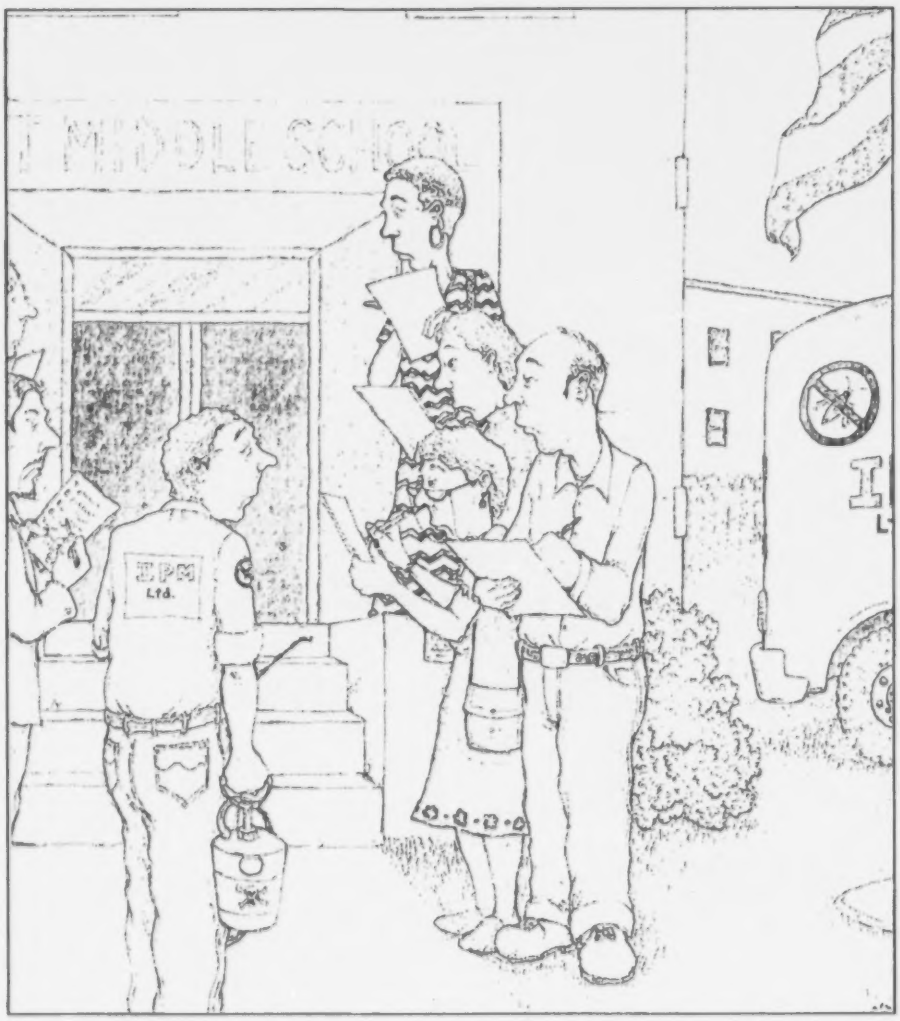

Section Four

Pesticides Commonly Used in Schools

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WHAT IS IN A PESTICIDE?

We normally think of a pesticide as the product that can be purchased in the store – the insecticide, the weed killer or the fungicide. But, unfortunately, there is much more to it than that. The product that you buy or are exposed to is actually a pesticide formulation that contains a number of different materials, including **active** and **inert ingredients**, as well as **contaminants and impurities**. In addition, pesticides, when subject to various environmental conditions, break down to other materials known as **metabolites**, which are sometimes more toxic than the parent material.

ACTIVE INGREDIENTS

The active ingredient, usually the only ingredient listed on the pesticide label, is by nature biologically and chemically active against a target pest, whether an insect, weed or fungus. By definition these chemicals kill living things.

INERT INGREDIENTS

If you were to go to your local hardware store and take a look at the label on a can of ant and roach killer, the contents might read something like this, "5% Permethrin, 95% Inert Ingredients." After reading the label, you may wonder what makes up the other 95%. The fact is that the manufacturer doesn't have to tell you. Currently, under the *Federal Insecticide, Fungicide and Rodenticide Act* (FIFRA), pesticide manufacturers are only required to list the active ingredients in a pesticide, leaving consumers and applicators unaware of the possible toxins present as inert ingredients. They are mixed into pesticides products as a carrier or sticking agent, and are often as toxic as the active ingredient, but do not have to be listed unless the EPA determines that they pose a public health threat. Pesticide manufacturers argue they cannot release information about inert ingredients because they are trade secrets and, if released, their products could be duplicated.

The Hazards of Inert Ingredients

Despite their name, these ingredients are neither chemically, biologically or toxicologically inert. In general, inert ingredients are minimally tested, but many are known to state, federal and international agencies to be hazardous to human health. For example, the U.S. government lists creosols as a "Hazardous Waste" under Superfund regulations, yet allows these chemicals to be listed as inert ingredients in pesticide products. Creosols are known to produce skin and eye irritations, burns, inflammation, blindness, pneumonia, pancreatitis, central nervous system depression and kidney failure. Some inert ingredients are even

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more toxic than the active ingredients. One of the most hazardous ingredients in the commonly used herbicide RoundUp® is a surfactant, which is classified as an inert, and therefore not listed on the label. The pesticide naphthalene is an inert ingredient in some products and listed as an active ingredient in others. According a 2000 report produced by the New York State Attorney General, *The Secret Ingredients in Pesticides: Reducing the Risk*, 72 percent of pesticide products available to consumers contain over 95 percent inert ingredients; fewer than 10 percent of pesticide products list any inert ingredients on their labels; more than 200 chemicals used as inert ingredients are hazardous pollutants in federal environmental statutes governing air and water quality; and, of a 1995 list of inert ingredients, 394 chemicals were listed as active ingredients in other pesticide products.

What Can Be Done?

Beyond Pesticides/NCAMP is working to convince EPA to require that all pesticide ingredients, including inerts, be listed on all pesticide product labels. In the mean time, because of a successful 1996 lawsuit (*NCAP and NCAMP v. Carol Browner, EPA)* filed by the Northwest Coalition for Alternatives to Pesticides (NCAP) and Beyond Pesticides/NCAMP against EPA, people may systematically request the ingredients are in specific pesticide product formulations, through the *Freedom of Information Act*. To obtain this information, a request must be made in writing to the Public Information Officer of EPA, EPA Office of Pesticide Programs, Freedom of Information Office H7506C, 401 M Street, SW, Washington, DC 20460. If you are member of a non-profit organization or seeking information "in the public interest," ask that your fees be waived "pursuant to 5 U.S.C. Section 522" and explain your tax status. Individual states also have similar laws, often called "Open Records Acts," which can be used. Visit the NCAP website for a sample request letter or reports on inert ingredients.

CONTAMINANTS AND IMPURITIES

Contaminants and impurities are often a hazardous part of the pesticide product. Dioxin and DDT have been identified as contaminants that have not been purposefully added, but are a function of the production process.

METABOLITES

Metabolites are breakdown products that form when a pesticide is used in the environment and mixes with air, water, soil or living organisms. Often the metabolite is more hazardous than the parent pesticide.

NON-TOXIC PEST MANAGEMENT TOOLS

Non-toxic pest management tools are those methods, products and techniques that do no put human health and the environment at risk from its use. Simple changes in your environment can significantly reduce pest populations. Before reaching for a pesticide, monitor the pest population, make structural repairs, use proper sanitation inside and outside, and modify the pest's habitat. Any openings that pests are using to access the structure should be caulked, screened or repaired. Some outdoor pests are attracted to spilled greasy or sugary liquids, improperly stored garbage, untended pet foods or explosions of naturally-occurring food sources like aphids or scale infestations on nearby plants. Efforts to eliminate food sources may eliminate the pest problems.

Following is a brief description of some alternatives to using toxic pesticides to control common pest problems.

COLD TREATMENTS

Liquid nitrogen can eradicate pests that can only live in a narrow temperature range. It is pumped into walls, freezing and killing the pest, and then warms and evaporates. Because nitrogen is a natural part of our atmosphere, it does not have the dangers associated with the use of synthetic pesticides. This method of pest control has been effective in controlling carpenter ants and dry wood and powder post termites.

CORN GLUTEN MEAL

The protein fraction in corn is an herbicide that inhibits root formation in a wide variety of grasses and broadleaf weeds during germination. It is a waste product from corn milling and has been used in fish food, dog food, and other animal foods. Corn gluten meal, because of its high nitrogen content can be applied to turf grass as a fertilizer and top dressing. Although large application rates are needed, it is an effective preemergent herbicide that suppresses growth of annual weeds such as crabgrass.

HEAT TREATMENTS

Heat is also effective in controlling pests that live in a narrow temperature range. Heat treatments require raising the temperature of a structure to 120° F or more. A heating unit, blowers and ducts carry the heat to the locations in the structure where the pests are causing damage. Heat treatment field tests have killed insects inside wood without damaging the building or furnishings, although certain sensitive appliances should be removed as a precaution. This method of pest

control has been effective in controlling carpenter ants, cockroaches , dry wood termites, fleas and wood-boring beetles.

This technology is called Thermal Pest Eradication™ and is marketed by Isothermics, Inc.

ELECTRICAL CURRENTS

Used to kill insects that nest in the walls of a structure, the Electorgun™ uses low wattage, high voltage, and high frequency to kill the insects. It does not emit microwaves, x-rays, ultraviolet rays or other potentially harmful radiation. Tests have shown the gun to be very effective. Existing pest holes and holes drilled into nests by the operator are used as entry points for the electricity. Tests show that some termites die immediately, and others may take weeks to die, but that they all die eventually. The Electorgun™ has been effective in controlling carpenter ants, cockroaches, wood boring beetles and drywood termites. It is manufactured and distributed by Contact Etex, Ltd.

LIVING BIOLOGICAL CONTROLS

The natural enemies of pests can be used to keep pest populations below damaging levels. These include spiders, lady bugs, lace wings, praying mantises, predatory mites, many parasitic flies and wasps and more. These species should be protected and encouraged to visit your lawn and garden. Many of today's pest problems were caused by the disruption of natural balances by toxic pesticides. By using living biological controls, you are only affecting the insects or plants it controls because they are host-specific, and therefore avoid the adverse human health and environmental effects associated with pesticides. Biological control works in an urban environment as well as in agriculture. Most beneficial species can be found online or via mail-order catalogs.

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OTHER NON-TOXIC PEST MANAGEMENT TOOLS

Aeration of soil
Black molasses
Calcium products/talc/lime
Caulk
Dehumidifiers
Door strips/door sweeps
Elimination of moisture sources
Fans
Flyswatters
Habitat modification
Hot pepper wax
Glue boards
Mowing high with sharp blades
Nest removal
Netting
Overseeding
Pruning
Sanitation
Sealing holes
Screens
Sodium chloride/salt
Sticky tape
Thatch removal
Traps (flytraps, sticky traps, pheromone traps, jar traps, insect light trap, etc.)
Vacuuming
Water drainage
Water pipe maintenance
Water spray

Compiled March 2001

Quarles, W. 1999. "Corn Gluten Meal: a Least-Toxic Herbicide." The IPM Practitioner 11(5/6)1-7.

LEAST-TOXIC PESTICIDES

Because of the high toxicity of conventional pesticides and the high levels of exposure to people and pests that result from their use, it is wise to avoid them. Pesticides are products that are designed to kill living organisms and should be treated with caution. If pesticides are used, it is best to go with baits or crack and crevice spot treatments and use the least toxic pesticide only after non-toxic alternatives have been tried.

The following list includes pesticides that are considered least toxic by Beyond Pesticides/NCAMP and acceptable for use as a last resort. Note that one concern that separates the toxic pesticide category from the least toxic pesticide category is the volatility of the chemical and its ability to vaporize or volatize into the ambient air. For instance, a bait with boric acid is non-volatile while a bait with chlorpyrifos is volatile.

It is important to remember that pesticides listed in this category still have the potential to cause harm to human health and the environment. It is also important to carefully read the labels on all products before use to make sure that they do not also contain toxic pesticides or synergists. If you are chemically sensitive, you will need to carefully evaluate whether the pesticide makes sense for you to use.

Baits, nonvolatile
Boric acid/borates/borax
Diatomaceous earth/silica aergoels
Fatty acid soaps/ insecticidal soaps
horticultural oils, vegetable base
Microbe based pesticides:
- Bio-blast
- B.t./B.t.i.
- Milky spore disease

Pesticides made with essential oils:
- Citrus oil
- Orange oil
- Garlic
- Pepper extracts
- Neem
- Sabadilla
- Tree oils

BAITS, NON-VOLATILE

Baits contain insect or rodent poisons mixed with food or other attractant. The principal behind most bait is that the pest will take some of the food containing the pesticide, and bring it back to the other members of its colony.

The volatility of the chemicals used in baits and their abilities to vaporize or volatize into the ambient air and therefore expose people to the chemical is a large concern. Volatile chemicals, like chlorpyrifos, used as the poison in baits put human health and the environment at risk. A bait containing a non-volatizing pesticide, like boric acid, is just as effective, if not more so, in controlling pest populations and doesn't pose the high risk for exposure.

Baits, by their very nature, are a better choice for pest control than sprays or broadcast applications. It is extremely important that baits are made of tamper resistant containers or for crack and crevice treatment, and are out of the reach of children.

Read the label (or ask your pest control service provider) to determine the poison or active ingredient in the bait, and then find that chemical's fact sheet.

Compiled March 2001

DIATOMACEOUS EARTH AND SILICA AEROGELS

USAGE

DE and silica aerogels are insecticidal dusts that kill pests by breaking through their outer cuticle. When the dust comes in contact with the pest, it abrades their outer shell, dehydrating and finally killing the pest.

Diatomaceous earth (DE), or silicon dioxide, a naturally-occurring material composed of the shells of minute, single-celled algae, and silica aerogels, formed by a reaction of sodium silicate and sulfuric acid to form fluffy aerogels, are dusts that controls insects by physically killing them and therefore do not pose the high risk that chemical pesticides do.

Although they are made of inert material and are relatively safe, care should be taken to avoid inhalation. Be aware that they have been combined with pyrethrin insecticides in various products; and there are serious health concerns associated with the use of pyrethrins.

TOXICITY

EPA documents state that the human health risk from exposure to DE is low and not unreasonable.[i] Although ingestion of diatomaceous earth is not toxic to mammals, long-term chronic inhalation exposure to DE can lead to possible health effects. Exposure to calcined, heated to 800°C DE tends to affect the lungs greater than exposure to naturally occurring DE.[ii] Studies show that DE has moderate to low acute toxicity due to acute oral and dermal effects and inhalation, eye, and dermal irritation. Product labels for dust formulations require the use of a dust mask.[iii]

With DE, it is important that natural, not swimming pool grade, be used. Swimming pool grade has been refined in such a manner that makes it more harmful to human lungs and is ineffective in controlling pests.

Silica aerogels are higher in acute toxicity and tend to kill insects more quickly than DE.

ECOLOGICAL EFFECTS

Silica aerogels are toxic to fish, so they should not be applied where they could run off into a stream, pond or lake.[iv]

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ENVIRONMENTAL FATE

Because the dusts are inorganic, they can remain effective for a very long time.

Compiled March 2001

[1] U.S. EPA. 1991. *R.E.D. Facts: Silicon Dioxide and Silica Gel*. 738-F-91-107. Office of Pesticide Programs. Washington, DC.

[1] Quarles, W. "Diatomaceous Earth for Pest Control." *The IPM Practitioner* 14(5/6): 1-11.

[1] U.S. EPA. 1991. *R.E.D. Facts: Silicon Dioxide and Silica Gel*. 738-F-91-107. Office of Pesticide Programs. Washington, DC.

[1] Olkowski, W., et al. 1991. *Common Sense Pest Control: Least Toxic Solutions for Your Home, Garden, Pets, and Community*. Taunton Press. Newtown, CT.

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ESSENTIAL OIL PESTICIDES

Pesticides made with essential oils are derived from plants that are known to have insecticidal properties. It is important to remember that just because a pesticide is derived from a plant does not mean that it is safe for humans and other mammals or that it cannot kill a wide variety of other life. Many pesticides made with essential oils are formulated with synergists. These have no insecticidal effect of their own, but serve to enhance the insecticidal effect of the botanicals. Carefully read the labels on all products before use to make sure that they do not also contain toxic pesticides. Some botanical pesticides can be quite toxic to humans and should not be used. Neem oil, garlic oil, and sabadilla are some least-toxic botanical pesticides listed below. Others that can also be used as a last resort are citrus oils, mint oil, pine oil, pepper extracts, tree oils and herbal extracts.

NEEM OIL

Extracted from the tropical neem tree, *azadirachta indica*, contains insecticidal properties that are composed of a complex mixture of biologically active compounds. It has a strong, unpleasant odor. Its various active ingredients act as repellents, feeding inhibitors, egg-laying deterrents, growth retardants, sterilants and direct toxins. Neem has both contact and systemic action in plants. The active ingredients biodegrade rapidly in sunlight and within a few weeks in the soil. Neem oil has very low toxicity to mammals. In India, neem products have been used in toothpaste, pharmaceuticals, and as a grain protectant for centuries without apparent harm to humans.[v]

GARLIC OIL

Garlic oil exhibits antibacterial, antifungal, amebicidal and insecticidal qualities. Although garlic oils kill pest insects and some pathogens, it also kills beneficial insects and microbes. Thus, it is not recommend as an all-purpose spray for outdoor use.

SABADILLA ALKALOIDS

Derived from the dried ripe seeds of a member of the lily family, *Schoenoxaulon officinate*, are often used as a broad spectrum low-persistence insecticide. Discovered by Native American peoples in northern South and Central America countries ago, it was used in wounds against vermin, and came to be used also by the Spanish invaders as a louse powder. The powdered seeds have been known to require aging to become fully active, but potency can be increased by heat treatment and extraction of the alkaloids into a solvent, like kerosene. The

alkaloids are photoreactive or unstable in the presence of light. Reported acute toxicity of the crude dust to mammals is low, with an oral rat LD50=500 mg/kg, but the purified sabadilla alkaloids are known to be toxic to bees. Sabadilla dust is very irritating to the upper respiratory tract, causing sneezing, and is irritating to the skin.[vi] Poisoning symptoms include: retching, muscle spasms, and especially, slowed heart beat and decreased blood pressure, not unlike that seen with the drug digitalis. The symptoms are slow to disappear. A researcher noted in 1901 that repeated small doses showed possible cumulative effects.

Compiled March 2001

[1] Bio-Integral Resource Center. 1987. "Update: Neem – A New Era in Pest Control Products?" *The IPM Practitioner* 9(10).
[1] U.S. EPA. 1999. *Recognition and Management of Pesticide Poisonings*. EPA 735-R-98-003. Office of Prevention, Pesticides, and Toxic Substances. Washington, DC.

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FATTY-ACID SOAPS

USAGE

Soaps, sodium or potassium hydroxide on a fat combined with vegetable oil, contain fatty acids, which act as an insecticide or herbicide killing pests on contact. Commonly used soaps containing potassium and coconut oil are effective in controlling many soft-bodies insects such as aphids, caterpillars, crickets, fleas, flies, and mites. When fatty-acid soap touches the outer body, or cuticle, of an insect or plant tissue it will eventually lead to dehydration and death of the pest.

Because fatty-acid soaps can kill a variety of arthropods, including those that are beneficials, outdoor use should be limited to spot treatments. Over use of soaps, like chemical pesticides, can lead to pest resistance (Olkowski 1991). Carefully read the label of the fatty-acid soap pesticide product to identify the active ingredient and make sure that they do not also contain toxic pesticides or synergists.

TOXICITY

These soaps are virtually nontoxic to humans or mammals unless ingested (Olkowski 1991).

ENVIRONMENTAL FATE

These soaps rapidly biodegrade in soil (Olkowski 1991).

Compiled March 2001

Olkowski, W. 1991. *Common-Sense Pest Control: Least-toxic solutions for your home, garden, pets and community.* Taunton Press. Newtown, CT.

HORTICULTURE OILS, VEGETABLE BASED

USAGE

Oils are hydrocarbons used as contact insecticides, acaricides, and ovicides. Kerosene was the first petroleum oil to be used for insect control in the early 1900's. Most horticulture oils used today are petroleum based (Grossman 1990), yet a growing number of horticulture oils are being made with vegetable oils, which are considered a least toxic pesticide. *Carefully read the label or ask your pest control service provider to determine if the horticulture oil is vegetable or petroleum based.*

Horticulture oils are effective in controlling aphids, adelgids, spider mites, mealy bugs, sawfly larvae, whiteflies, plant bugs, caterpillars, scales, and some plant diseases like rusts and mildews (Olkowski 1991). They flood insects breathing pores which lead to prompt asphyxiation and suffocation.

Horticulture oil sprays are formulated with a detergent or soap surfactant in order to keep the product from separating. Adding soaps to horticulture oil products also increase the effectiveness of its insecticidal properties. There are several types of formulations of oils: dormant oils, summer oils, emulsifiable oils and stock emulsions. Dormant oils are extremely phytotoxic with varying degrees of susceptibility between varieties and species. Dormant oils tend to contain a higher level of impurities, but modern refining techniques have removed a high percentage of phytotoxic impurities (Grossman 1990).

Horticulture oils have not been found to lead to insect resistance (Thomson 1983).

TOXICITY

Because of horticulture oils mode of action, they do not pose the high exposure risk that chemical pesticides do. Horticulture oils have relatively low mammalian toxicity (Grossman 1990). Petroleum based horticulture oils can cause skin and eye irritation (Olkowski 1991).

Horticulture oils that are vegetable based are equally as effective in killing certain insects as oils that are petroleum based (Grossman 1990). Vegetable based oils are similar in mode of action, application method, and phytotoxicity. Vegetable based horticulture oils do not leave residues behind like petroleum based oils.

Compiled March 2001

Grossman, J. 1990. "Horticultural Oils: New Summer Uses on Ornamental Plant Pests." *The IPM Practitioner* 12(8):1-10.

Olkowski, W. 1991. *Common-Sense Pest Control: Least-toxic solutions for your home, garden, pets and community*. The Taunton Press. Newtown, CT.

Thomson, W.T. 1983. *Agricultural Chemicals - Book I Insecticides*. Thomson Publications: CA.

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MICROBIAL PESTICIDES

Certain microbes are effective in controlling insect, fungus, and weed pest problems and are virtually nontoxic. Microbial pesticides contain living microorganisms or the toxins they produce as active ingredients. Following are just a few examples.

MILKY SPORE DISEASE

Bacillus popilliae is a nontoxic way to control grubs. Commercial milky spore dust is made by inoculating beetle grubs with the disease and then extracting the spores, which resemble dust or powder when dry. The spores can be applied any time except when the ground is frozen or a strong wind is blowing. Grubs become infected when they feed on the thatch or roots of grass where the spores have been applied. As the infected grubs move about in the soil, then die and disintegrate, they release one or two billion spores back into the soil. This spreads the disease to succeeding generations of grubs. If the conditions are right, grub population high and feeding vigorously, and soil is at least 70 degrees F and very moist, the disease can spread through the grub population in a week or two. In general, however, the disease should not be thought of as a quick knockdown insecticide. It may take a season or two before it has a substantial impact. It can remain effective for a decade.

BACILLUS THURINGIENSIS (B.T.)

A naturally occurring soil bacterium, B.t. it is a spore-forming rod and an insect pathogen. Different strains are toxic to particular kinds of insects. There are nearly 400 registered products that have been marketed in the country, providing effective control of such major insect pests as gypsy moths, mosquitoes, blackflies, and many others. These B.t. strains are only effective against insects in their larval feeding stages, since B.t. must be ingested to be effective. Depending on how much B.t. is ingested, insect larva soon stop feeding and are dead in a few days to a few weeks. B.t. is completely biodegradable, and does not persist in the digestive systems of birds or mammals. There is no evidence that B.t. goes on to reproduce in the wild. B.t.'s short biological half-life and high specificity makes the development of field resistance much more unlikely than with chemical pesticides if used in a targeted fashion. Infections of humans have been extremely rare. Neither irritative nor sensitizing effects have been reported in workers preparing and applying commercial products.[vii] B.t. is toxic to most caterpillars.

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BENEFICIAL NEMATODES

These microscopic soil-dwelling worms actively search for insects like pre-adult fleas, fire ants, or termites in the yard. After invading the larvae or pupae, they release a bacterium that kills the host within 48 hours. The nematodes then feed on the pest's body, reproduce and seek out more pests. When all larvae and pupae are killed, the nematodes die off and biodegrade. Numerous pest problems can be controlled or eliminated by using biological controls that have a minimal impact on non-target species and offer long-term solutions. Nematodes are effective in controlling ants, fleas, flies, Japanese beetles and grubs, termites, worms and caterpillars, among others.

BENEFICIAL FUNGUS PATHOGENS

Beauveria spp., is a fungus that is used as a pesticide for controlling many kinds of insects. Many strains of this fungus are found worldwide in the soil. They control insects by growing on them, secreting enzymes that weaken the insect's outer coat, and then getting inside the insect and continuing to grow, eventually killing the infected pest. Available EPA information indicates that use of *Beauveria* spp. as a pesticide is not expected to adversely affect people or the environment and tests show that the fungus is not toxic to mammals, birds or plants. There is a potential for pesticide products containing the fungus to harm bees, so the products must not be applied near beehives or where bees are actively hunting for food.[viii]

Compiled March 2001

[1] U.S. EPA. 1999. *Recognition and Management of Pesticide Poisonings*. EPA 735-R-98-003. Office of Prevention, Pesticides, and Toxic Substances. Washington, DC.

[1] U.S. EPA. 1999. *Biopesticide Fact Sheet Beauveria bassiana strain GHA (128924)*. <http://www.epa.gov/oppbppd1/biopesticides/factsheets/fs128924e.htm>.

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TOXIC PESTICIDES

Because of the high toxicity of conventional pesticides and the high levels of exposure to people and pests that result from their use, it is wise to avoid them. Pesticides are products that are designed to kill living organisms and should be treated with caution. If pesticides are used, it is best to go with baits or crack and crevice spot treatments and use the least toxic pesticide only after non-toxic alternatives have been tried.

Toxic pesticides are found in thousands of products that are used in your home, garden, school, workplace, parks, along rights-of-way and on farms. They are used to kill a range of pests, including insects, rodents, weds, fungi, bacteria and mildew. They can be inhaled, absorbed through your skin, and ingested. Many people assume that, because pesticides use is so common, it must not be harmful, but U.S. EPA registration of a pesticide does not mean that it is safe.

The chart below lists the commonly used pesticide active ingredients that are toxic to human health and the environment and are not recommended for use. This category contains pesticides that are determined by U.S. EPA to be a possible, likely, or known carcinogen, mutagen, teratogen, reproductive toxin, developmental neurotoxin, endocrine disrupter, and/or immune system toxin.

Health Effects of 48 Commonly Used Pesticides in Schools

Pesticide	Cancer	Reproductive Effects	Neurotoxicity	Kidney / Liver Damage	Sensitizer / Irritant	Birth Defects
Insecticide						
Acephate	C	X[i]	X[2]		X[1]	
Allethrin			X[1]	X[1]	X[1]	
Avermectin		X[1]	X[1]		X[1]	X[1]
Bendiocarb			X[i]		X[1]	
Bromacil	C			X[1]	X[i]	
Chlorpyrifos		X[i]	X[2]		X[1]	X[1]
Cyfluthrin		X[1]	X[1]	X[1]	X[1]	
Cypermethrin	C		X[1]	X[1]	X[1]	
Diazinon		X[i]	X[2]	X[3]	X[1]	
Dichlorvos	C, 2B		X[2]	X[1]	X[1]	
Fenoxycarb	B2			X[1]	X[1]	
Fenvalerate			X[1]		X[1]	
Hydramethylnon	C	X[2]		X[1]	X[1]	X[2]
Isophenfos			X[2]		X[1]	

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Pesticide	Cancer	Reproductive Effects	Neurotoxicity	Kidney / Liver Damage	Sensitizer / Irritant	Birth Defects
Lamda Cyhalothrin	D		X[1]		X[1]	
Lindane	B2	X[1]	X[3]	X[3]		
Phenothrin						
Piperonyl Butoxide	C	X[3]	X[3]	X[3]	X[i]	
Prometon	D					
Propetamphos			X[2]			
Propoxur	B2	X[1]	X[2]	X[1]		X[1]
Pyrethrin		X[1]	X[1]	X[1]	X[1]	
Tetramethrin	C					
Trichlorfon		X[1]	X[2]	X[1]	X[1]	X[1]
Herbicides						
Atrazine	C, 2B		X[1]	X[1]	X[1]	X[i]
Bensulide			X[3]	X[i]	X[1]	
2,4-D	X[i]	X[1]	X[1]	X[3]	X[1]	X[1]
DSMA			X[i]		X[7]	
Dacthal	C			X[3]	X[3]	
Dicamba	D	X[1]	X[1]	X[1]	X[1]	
Diquat Dibromide		X[3]	X[3]	X[3]	X[3]	X[3]
Endothall		X[1]		X[1]	X[1]	
Glyphosate		X[3]		X[1]	X[3]	
Isoxaben	C			X[3]		X[3]
MCPA		X[1]	X[1]		X[1]	X[1]
MCPP		X[1]	X[i]	X[1]	X[1]	X[1]
MSMA			X[13]		X[13]	
Pendimethalin	C	X[1]		X[1]	X[1]	
Pronamide	B2	X[3]		X[3]	X[1]	
Siduron					X[13]	
Triclopyr	D	X[3]		X[3]	X[3]	
Trifluralin	C	X[1]		X[1]	X[3]	
Fungicides						
Benomyl	C	X[i]	X[3]	X[1]	X[1]	X[14]
Chlorothalonil	X[i]	X[3]	X[3]	X[1]	X[3]	
Maneb	B2	X[1]	X[1]	X[1]	X[1]	X[1]
PCNB	C			X[1]	X[1]	X[3]
Sulfur					X[3]	
Triadimefon	C	X[14]	X[3]	X[1]		X[14]
Ziram		X[1]	X[1]		X[1]	X[1]

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Pesticide	Cancer	Reproductive Effects	Neurotoxicity	Kidney / Liver Damage	Sensitizer / Irritant	Birth Defects
TOTAL	21 probable or possible	26	31	31	41	16

B2 = EPA weight-of-evidence category, "probable human carcinogen, sufficient evidence in animals and inadequate or no evidence in humans."
C = EPA weight-of-evidence category, "possible human carcinogen" rating.
D = EPA weight-of-evidence category, "not classifiable as to human carcinogenicity," usually due to inadequate data.
2B = International Agency for Research on Cancer, World Health Organization (IARC) category, the agent (mixture) is possibly carcinogenic to humans.
X = Adverse effect demonstrated.

[1] Extension Toxicology Network (EXTOXNET) Pesticide Information Profiles, ace.orst.edu/info/extoxnet/ghindex.html.
[2] California Department of Pesticide Regulation.
[3] EPA's Office of Pesticide Program Reregistration Eligibility Decision (RED) Factsheet, www.epa.gov/oppsrrd1/REDs/.
[4] EPA's Office of Prevention, Pesticides and Toxic Substances, Revised Risk Assessments on Chlorpyrifos (Released 8/16/00).
[5] Environmental Defense Fund, Scoreboard Database, www.scorecard.org/chemical-profiles/.
[6] Farm Chemicals Handbook, 2000.
[7] New Jersey Department of Health and Senior Services, Hazardous Substances Factsheet.
[8] Human Health Risk Assessment for Bensulide, EPA's OPP Health Effects Division.
[9] Based on National Cancer Institute epidemiological evidence.
[10] Material Data Safety Sheet for DSMA, www.horizononline.com/MSDS_Sheets/195.txt.
[11] National Library of Medicine, TOXNET, Hazardous Substances Database, http://toxnet.nlm.nih.gov/.
[12] Classified under California Department of Pesticide Regulation's Proposition 65.
[15] EPA classifies chlorothalonil as a "Likely" carcinogen, under proposed EPA weight-of-evidence category, because the available tumor effects and other key data are adequate to convincingly demonstrate carcinogenic potential for humans.

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ACEPHATE

USAGE

This systemic, broad-spectrum organophosphate insecticide, known by the trade name Orthene™, is produced by the Chevron Chemical Co. It is widely used in agriculture, seed production, in greenhouses, on turf and on commercially grown ornamentals, sometimes in combination with other pesticides. EPA has not produced a Reregistration Eligibility Document for acephate, but they required acephate product labels to contain the signal work CAUTION because of its toxicity category III rating (EXTOXNET 2001). They have also imposed an interim worker reentry period of 24 hours for commercial use, and protective clothing requirements.

TOXICITY

Although acephate is only moderately acutely toxic, with an oral rat LD50 (lethal dose needed to kill 50% of the test population) of 500 to 1000 mg/kg, the state of California reported 39 incidents of acephate poisoning between 1982 and 1986, most (25/39) involved applicators who were exposed to the concentrated material. In common with other organophosphates, acephate inhibits acetylcholine esterase (AchE), an essential nervous system enzyme, causing characteristic symptoms such as headaches, fatigue, stomach cramps, nausea, and in extreme cases, respiratory depression.

Interestingly, technical acephate is more acutely toxic than the purified form, because technical acephate contains as much as 30% of a more toxic breakdown product, methamidophos, another organophosphate pesticide known as Monitor™. Another impurity, methylthioacetate (MTA), can be found in small amounts in acephate formulations, and further testing is being required to address its significance. One acute dermal toxicity study in rabbits found that MTA could cause blindness when applied at concentrations between 1500 and 3000 mg/kg.

EPA published a Registration Standard on acephate in September, 1987, which reviewed the existing database and data gaps needing to be filled. According to the Agency, acephate is quickly cleared, does not bioaccumulate, and is excreted mostly as the unchanged compound, although a small amount of methamidophos (also quickly excreted) is formed by intestinal microbes in the rat.
Chronic toxicity effects were all related to AchE inhibition. A single, insensitive, neurotoxicity test found no delayed neurotoxicity. Acephate has not been found to cause birth defects in rats and rabbits. However, in a reproductive effects test,

a "non-observable-effects-level (NOEL)" was never established, and low pregnancy rates, high loss of litters and decreased numbers of live fetuses were observed in every treatment group, 50 ppm (parts per million) and higher.

EPA has classified acephate as a Category C or possible human carcinogen. Oncogenicity test results found an increased incidence of adrenal medullary tumors and pituitary tumors in male rats when compared with experimental controls. In female mice, an increased incidence of liver tumors and liver hyperplastic nodules, thought to be precursors to tumors, was seen at the highest doses tested. Acephate is mutagenic in shor-term assays, but not in tests conducted *in vivo*, on live animals.

ECOLOGICAL EFFECTS

Acephate, and especially methamidophos, are highly toxic to bees, and moderately toxic to birds. EPA stated, "studies indicate that acephate treatments may result in local population reductions in some avian species as well as a high incidence of sublethal AchE inhibition..." although EPA did not feel that long-lasting harm to bird populations would occur.

ENVIRONMENTAL FATE

Although acephate dissipates rapidly from aerobic soil with half-lives of three to six days, it is, according to EPA," mobile in most soils [therefore] the potential for groundwater contamination exists ...[however]...most of the applied acephate and the breakdown product methamidophos degrade to immobile compounds within 20 days...[and therefore]...the probability of contamination is limited." The USDA reviewed studies conducted by Chevron in the early 1970's and reported in a review, "Orthene™ has a longer half-life on foliar surfaces than in soil or water...in studies using lettuce, broccoli and cotton leaves, only an average of 5% of the applied Orthene™ could be washed off leaves three, seven and fourteen days after treatment at two lbs/acre."

Revised April 2001

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AVERMECTIN/ ABAMECTIN

USAGE

The active ingredient of many abamectin products, like Avid™, Zephyr™, Vertimec™ or Agri-Mek™, is actually a mixture of 80% avermectin B_{1a} and 20% avermectin B_{1b} (FCH 2000). These B_{1a} and B_{1b} avermectins are purified from a chemically complex insecticidal/miticidal toxin produced by an actinomycete bacterium, *Streptomyces avermitilis*, found in soil. Although, abamectin is a natural fermentation product of this bacterium, the pesticide is classified by the U.S. Environmental Protection Agency (EPA) as a class II toxicity pesticide on a scale of I to IV, I being the most toxic.

Like most other insecticides, avermectins are nerve poisons. They stimulate the gamma-aminobutyric acid (GABA) system, a chemical "transmitter" produced at nerve endings, which inhibits both nerve to nerve and nerve to muscle communication. The affected insect becomes paralyzed, stops feeding, and dies after a few days. Avid™, used against mites and leaf-miners, is said to spare some of the major parasites of the miner and some predacious mites. When applied to foliage, it is absorbed by the leaves, where feeding insects encounter the poison.

TOXICITY

Technical avermectin is quite acutely toxic, with an oral rat LD_{50} (lethal dose for 50% of the test rats) of 30 mg/kg. EPA reviewed toxicological data from the manufacturer in connection with a 1987 petition for establishment of a tolerance in citrus oil and citrus pulp. EPA's reviewers found that avermectin does not cause birth defects in rats and rabbits, but can cause cleft palate in mice. The calculated "lowest effect level (LEL)" for the latter effect was quite low at 0.10 mg/kg/day. EPA reviewers stated that "studies on mutagenicity demonstrated an overall negative potential (ETN 1996).

Abamectin has been shown to cause pupil dilation, mild skin irritation, vomiting, convulsions and/or tremors and coma in laboratory animals. Because it is a nerve poison, it can also cause nervous system depression in mammals at very high doses. A study in rats given 0.40 mg/kg/day of abamectin showed decreased lactation, increased stillbirths and an increased likelihood of producing unhealthy offspring, demonstrating a strong chance of similar effects in humans at high enough doses. Abamectin is also very toxic to fish and aquatic invertebrates (FCH 2000).

ENVIRONMENTAL FATE

Abamectin is broken down quickly in the soil via photodegradation at the soil surface and microbial degradation in dark, aerobic conditions. The chemicals half-life is about 1 week on an unshaded soil surface and about two weeks to two months underneath the soil surface. It is also rapidly broken down in water, its half-life being four days in pond water and two to four weeks in pond sediment (ETN 1996).

Revised March 2001

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BAITS, VOLATILE

Baits contain insect or rodent poisons mixed with food or other attractant. The principal behind most bait is that the pest will take some of the food containing the pesticide, and bring it back to the other members of its colony.

The volatility of the chemicals used in baits is a large concern. Many chemicals can vaporize or volatize into the ambient air and expose people to the chemical. Volatile chemicals, like chlorpyrifos, used as the poison in baits puts human health and the environment at risk. A bait containing a non-volatizing pesticide, like boric acid, is just as, if not more, effective in controlling the pest population and doesn't pose the high risk for exposure.

Baits, by their very nature, are a better choice for pest control than sprays or broadcast applications. It is extremely important that baits are made of tamper resistant containers or for crack and crevice treatment, and are out of the reach of children.

Read the label (or ask your pest control service provider) to determine what the poison, or active ingredient, is in the bait, then find that chemical's fact sheet on this website.

Compiled March 2001

BENDIOCARB

Bendiocarb is a widely used carbamate insecticide with high acute toxicity. Due to the manufacturer's request for voluntary cancellation of all bendiocarb products on August 18, 1999, all products are being phased-out. End use products used in and around homes have been prohibited to be sold or distributed by the registrant since October 31, 2000, and all bendiocarb products will be cancelled as of December 31, 2001 (U.S. EPA 1999).

USAGE

Consumers are most familiar with Ficam D™, a 1% dust, and Ficam W™, an 80% wettable powder, for use by professional applicators. Both formulations are used in structural pest control against cockroaches, ants, fleas and crickets. Ficam Plus™, used with synergized pyrethrins (NCAMP 1986). Dycarb™ is registered for use on plant insect pests like aphids, scale, whitefly, lace bugs and mealy bugs on horticultural crops. Turcam™ is registered for use on turf and ornamentals, and Turcam ULV™, an ultra-low volume formulation, is registered for mosquito control (U.S. EPA 1985).

TOXICITY

Carbamate insecticides are nervous system poisons. They bind to the active site of the enzyme acetylcholine esterase (AchE), which is necessary for normal function of nerve impulses to other nerves and muscles. This causes an accumulation of acetylcholine, an excitatory neurotransmitter, at nerve muscle sites resulting in poisoning symptoms. Unlike their close relatives, the organophosphates, examples of which include Dursban ™, parathion, and diazinon, carbamates do not bind permanently to the enzyme and can be "dislodged" from the active site, so that poisoning effects are readily reversible, upon administration of the antidote atropine. Carbamates, however, can be more acutely toxic. Bendiocarb has a particularly high acute toxicity. The oral rat LD_{50} is 34-156mg/kg (lethal dose that will kill 50% of the test population); cats are eight times more sensitive.

It is suspected that carbamates can act at other sites in the nervous system as well. Symptoms of poisoning include diarrhea, nausea, vomiting, stomach cramps, sweating, blurred vision, muscle twitching or jerking, which last only a few hours if exposure is interrupted. Continued exposure can result in malaise, weakness and symptoms that mimic the flu. Because carbamates dissociate so readily from AchE, blood tests for reduced activity of AchE are of limited use in documentation of a poisoning episode.

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Bendiocarb has been classified as a 'Group E' carcinogen by the EPA, showing no evidence of carcinogenicity in laboratory animals or in humans (U.S. EPA 2000). Available information indicates that bendiocarb does not cause reproductive effects or birth defects in animals. It can cause skin rashes in rabbits, but is not a skin sensitizer. In a chronic study performed in mice, hyperactivity and lenticular opacities (eye problems) are noted in an interim report, with no information on the test's outcome. Another chronic study performed on rats fed 10mg/kg/day showed various changes in organ weights, blood, urine characteristics and increased incidence of stomach and eye lesions. A metabolism study of men indicates that bendiocarb clears within 3 hours in the urine.

ECOLOGICAL EFFECTS

Moderate toxicity has been seen in birds with an LD50=3.1 mg/kg in mallard ducks. Bendiocarb is toxic to fish, earthworms and bees (U.S. EPA 1985).

ENVIRONMENTAL FATE

Other insecticides of the carbamate class, aldicarb and carbofuran, are of concern due to their demonstrated ability to contaminate groundwater. According to an EPA official, information submitted in response to a Data Call-In stated that bendiocarb is a potential leacher.

At pH 5, approximating that of rainwater, bendiocarb is fairly stable, showing no appreciable breakdown after 30 days. Bendiocarb breaks down more readily at more alkaline pHs, with a half-life of 10 days at pH 7, to 2,2-dimethyl1,3-benzodioxyl-4-ol, a phenol, and carbon dioxide. Bendiocarb is metabolized by soil microorganisms in soils with organic content, but in low-oxygen, low-organic content soils, this process is retarded.

Revised April 2001

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CHLORPYRIFOS

On June 8, 2000, the U.S. Environmental Protection Agency (EPA) and Dow AgroSciences, reached an agreement to stop the sale of most home, lawn and garden uses for chlorpyrifos because of its health risks to children.

USAGE

Chlorpyrifos (trade names include Dursban™ and Lorsban™) is one of the most widely used insecticides in the U.S., with 20 to 24 million pounds applied annually, and has been linked to thousands of pesticide poisoning incidents. This Dow AgroSciences, previously DowElanco, product is a broad-spectrum chlorinated organophosphate insecticide.

Chlorpyrifos is registered for the control of cutworms, corn rootworms, cockroaches, grubs, flea beetles, flies, termites, fire ants, mosquitoes, and lice. It is used as an insecticide on grain, cotton, fruit, nut, and vegetable crops, as well as on lawns and ornamental plants. It is also registered for direct use on sheep and turkeys, for horse site treatment, dog kennels, domestic dwellings, farm buildings, storage bins, and commercial establishments.

TOXICITY

Chlorpyrifos is acutely toxic to rats with an LD_{50} of 135 mg/kg.

Chlorpyrifos poisoning may affect the central nervous system, the cardiovascular system and the respiratory system, as well as irritate the skin and eyes. Acute exposure can result in numbness, tingling, incoordination, dizziness, vomiting, sweating, nausea, stomach cramps, headache, vision disturbances, muscle twitching, drowsiness, anxiety, slurred speech, depression, confusion and in extreme cases, respiratory arrest, unconsciousness, convulsions, and death. Persons with respiratory ailments, recent exposures to cholinesterase inhibitors, cholinesterase impairment, or liver malfunction are at increased risk from exposure to chlorpyrifos. Chlorpyrifos has also been linked to Multiple Chemical Sensitivity.

Chlorpyrifos is linked to delayed peripheral neuropathy (degenerative lesions of sensory, motor, or reflex nerves). Italian researchers published a disturbing report of an acute chlorpyrifos-poisoning episode, resulting in delayed peripheral neuropathy. There are also reports of EEG (brainwave) pattern, sleep pattern and behavioral changes lasting over a year following exposure to organophosphate insecticides.

Organophosphates are cholinesterase inhibitors. They bind irreversibly to the active site of an enzyme essential for normal nerve impulse transmission, acetylcholine esterase (AchE), inactivating the enzyme. A common diagnostic for poisoning is to assay for blood AchE depression. Repeated or prolonged exposure to organophosphates may result in the same effects as acute exposure, including delayed symptoms.

A 1996 study of children exposed to chlorpyrifos in utero found that extensive and unusual patterns of birth defects, including brain, nervous system, eyes, ears, palate, teeth, heart, feet, nipples, and genitalia. Published literature and EPA documents contain reports that identify similarities in defects found in test animals and children exposed to chlorpyrifos.

In 1997, EPA Office of Pesticide Programs', Health Effects Division reported that chlorpyrifos is one of the leading causes of acute insecticide poisoning incidents in the U.S. One U.S. News & World Report investigation, "The stuff in the backyard shed," (November 8, 1999, page 64-68) reports that since 1992, Dow AgroSciences and predecessor manufacturers have sent approximately 7,000 reports of chlorpyrifos-induced reactions to EPA. The agency, according to the report, suspects chlorpyrifos in 17,771 incidents reported to the U.S. Poison Control Centers between 1993 -96.

In 1999, EPA's Office Pesticide Programs, Health Effects Division, reported that four pesticides, phosmet, proetamphos, chlorpyrifos, and dimethoate, had consistently high rankings in being responsible for symptoms, health care facility visits, hospitalizations, and fatal outcomes in adults and children. These four organophosphate pesticides are responsible for 90% of pesticide exposures reported in children under six to the Poison Control Centers around the country from the 1993-1996. The report also stated that "children, under six exposed to organophosphates, were three times more likely to be hospitalized, five times more likely to be admitted for critical care, and four times more likely to have experienced a major medical outcome or death, than if exposed to some other, non organophosphate, pesticide."

In animals, chlorpyrifos transforms to chlorpyrifos-oxon, which is about 3000 times as potent against the nervous system as chlorpyrifos itself.

ECOLOGICAL EFFECTS

There is a wide range of adverse environmental effects linked to chlorpyrifos, include toxicity to beneficial insects, freshwater fish, other aquatic organisms, bird, a variety of plants, soil organisms, and domestic animals. It has been shown to bioaccumulate in fish and synergistically react with other chemicals.

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Chlorpyrifos may be toxic to some plants, such as lettuce.

ENVIRONMENTAL FATE

There are few data available on air levels or surface residues following application either as a termiticide or for indoor pest control. The American Conference of Governmental Industrial Hygienists recommends an occupation air level guideline of 200-micrograms/cubic meter ($\mu g/m^3$) for a forty-hour workweek. The National Academy of Sciences proposed a $10\mu g/ m^3$ air level for the general public, while EPA has proposed an air limit of $0.49\mu g/m^3$ for children, and $1\mu g/ m^3$ for adult exposures.

Work by Fenske *et al.* found that air levels 24 hours after a proper application were as high as $30\mu g/ m^3$ in the infant breathing zone, 60 times EPA's limit. Furthermore, Fenske calculated that infant exposure through inhalation and skin absorption might be more than five times the human threshold for acute effects (No Observable Effect Level). The researchers state that, "Exposures to cholinesterase inhibiting compounds following properly conducted broadcast applications could result in doses at or above the threshold of toxicological response in humans."

In common with most organophosphates, chlorpyrifos has a relatively short biological half-life, roughly 24 hours in blood, and 60 hours in fat (assuming that multiple or continuous exposure does not occur) and it has shown no potential to bioaccumulate in mammals. Its half-life ir doors is estimated to be 30 days. Various studies of different treatment methods show chlorpyrifos present up to eight years post application. A 1998 study found that chlorpyrifos accumulated on furniture, toys, pillowcases, and other sorbant surfaces up to two weeks after indoor application.

Chlorpyrifos is sensitive to light, alkaline substances such as bleach, and microbial degradation. Eventually, it degrades completely to carbon dioxide and water. The half-life of chlorpyrifos in water is relatively short, from a few days to two weeks. It adsorbs readily to sediments and organic matter, its half-life in soil is usually between 60 and 120 days, but can range from 2 weeks to over one year, depending on the soil type, climate, and other conditions.
Residues remain on plant surfaces for approximately 10 to 14 days. Data indicate that this insecticide and its soil metabolites can accumulate in certain crops.

The granular formulation of chlorpyrifos has been found to be more persistent and may persist as long as 180 days. The major biological metabolite and environmental breakdown product is 3,5,6-trichloro-2-pyridinol (TCP).

According to an EPA memorandum, groundwater monitoring at a Cape Cod golf course detected TCP in samples. Reports from the USDA Southern Forest Experimental Station note that the termiticide formulation is effective against termites for more than 15 years.

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2,4-D

USAGE

2,4-D is the most widely used herbicide in the non-agricultural sector with 23-27 million pounds used annually (U.S. EPA 1999). All 2,4-D products are required to carry the DANGER signal word on the label indicating its EPA toxicity rating of I, the highest of four categories. The U.S. Environmental Protection Agency (EPA) has not fully evaluated 2,4-D's effects on human health and the environment.

Industry reports show that amine salt formulations of 2,4-D may become contaminated during synthesis with up to several hundred parts per billion of nitrosamines, known to be potent carcinogens. Several forms of dioxin have been identified in 2,4-D, including 2,3,7,8-tetrachlorodibenzo-p-diozin (also known as TCDD, the most toxic of the dioxin family, at levels greater than one part per billion); 1,3,7,9 and 1,3,6,8-TCDD; 2,7-dichlorodibenzo-p-dioxin; and 1,2,4- and 1,3,7-trichlorodioxins. The dioxins can cause cancer, birth defects, reproductive effects, liver damage and chloracne. Other contaminants include 1,3,6,8-tetrachloroxanthone (TCX) and 2,4-dichlorophenol.

TOXICITY

According to EPA, 2,4-D is irritating to the eyes, skin and mucous membrane and since it is easily absorbed dermally or by inhalation, can injure liver, kidney, muscle and brain tissues. Acute symptoms of exposure include: chest and abdominal pain, vomiting, dizziness and muscle twitching, tenderness or stiffness (U.S. EPA 1982). Studies in rats have demonstrated that 2,4-D can migrate into nervous tissue and concentrate in certain areas of the brain. Not too surprisingly, behavioral changes have also been observed in treated rats (Evangelista de Duffard 1990). In humans, seemingly minor dermal exposures have bee known to cause peripheral neuropathy (irreversible loss of feeling in the extremities). Depression, lethargy and coma have also been documented in animals and humans.

2,4-D is a mutagen. In laboratory tests it has mutagenic effects on human lymphocytes and human fibroblasts. Genotoxicity has even been documented in plants. Reproductive toxicity has been observed in animals at high dose levels. Exposure resulted in fetuses with abdominal cavity bleeding, increased mortality and inhibition of DNA synthesis in the testes (ETN 1996). A study of male farmers also demonstrated reduced sperm counts and sperm abnormalities in 2,4-D exposed farmers, and abnormalities were still apparent even one year after exposure.

The findings on carcinogenicity add to the already incriminating body of evidence about 2,4-D, including a manufacturers' study submitted to EPA in June 1986, indicating the herbicide, which is widely used in agriculture, forestry and urban settings, can cause rare brain tumors (astrocytomas) in rats. These studies indicate a need for closer examination of other commonly used phenoxies such as dichlorprop, mecoprop (MCPP), MCPA and 2,4,5-T (banned in the U.S.).

A 1988 National Cancer Institute (NCI) study, conducted by Drs. Sheila Hoar and Aaron Blair, examined all cases of diagnosed cancer among Kansas farmers between 1976 and 1982. According to the study, farmers who were exposed to 2,4-D for 20 or more days per year had a sixfold higher risk of developing non-Hodkin's lymphoma than non-farmers, while farmers who mixed or spread the herbicide had an eightfold higher risk of developing the tumor. Significantly, the researchers noted that farmers who took precautions to minimize their exposure were at lesser risk (Hoar-Zahm 1988). Dr. Hoar also published a 1990 study of Nebraska farmers, which demonstrated a 50% increase in non-Hodgkin's lymphoma for growers who handle 2,4-D. The linkage between 2,4-D exposure and non-Hodgkin's lymphoma has also been documented in Sweden, Canada, Nebraska and Washington (Zahm 1990).

A 1991 NCI study found that dogs, whose owners' lawns were treated with 2,4-D four or more times per year, were twice as likely to contract canine malignant lymphoma than dogs whose owners did not use the herbicide. Malignant lymphoma in dogs is considered very similar to non-Hodgkin's lymphoma in humans (Hayes 1991).

In addition to these studies, a bioassay conducted by the Food and Drug Administration found increased incidences of lymph sarcoma (malignant tumors) in both male and female rats, breast tumors in female rats and reticulum cell sarcoma (malignant blood cell tumors) in male rats exposed to 2,4-D. The latter were also found in mice exposed to the iso-octyl salt of 2,4-dichlorophenol, major breakdown product, to be a cancer promoter.

Even with all the mounting evidence, EPA has listed 2,4-D as a Group D chemical for its carcinogenic potentia, or as having inadequate human and animal evidence of carcinogenicity or no data available (U.S. EPA 2000).

TOXICITY

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ECOLOGICAL EFFECTS

2,4-D is slightly toxic to wildfowl (mallards, pheasants, quail and pigeons), while some formulations are highly toxic to fish. Moderate doses of the chemical fed to honeybees caused severe impairment of blood production.

ENVIRONMENTAL FATE

A systemic herbicide, 2,4-D is easily absorbed by foliage and translocated throughout the treated plant, which dies in 7-14 days. Phenoxy acid herbicides like 2,4-D mimic the action of natural plant growth regulators known as auxins, causing treated plants to literally grow themselves to death. In soil, 2,4-D residues usually dissipate within a month, primarily due to microbial degradation). 2,4-D is known to leach from soils low in clay or organic content and in cool, dry, nutrient-poor soils. Under these conditions, residues may persists for several months.

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DIAZINON

USAGE

Diazinon is an organophosphate insecticide; common trade names include Spectracide™, Knoxout™, Basudin™. It is the fifth most commonly used pesticide used by homeowners, with two to four million pounds used annually.

Diazinon originated with Ciba-Geigy in 1952. Various diazinon formulations are widely used in agriculture, for structural pest control, on lawns, and in home gardens. Important target pests for diazinon applications include cockroaches, aphids, scales, mites, ants, crickets, fleas and ticks, flies, grubs, and yellow jackets. Depending on form, the EPA has classified diazinon as a toxicity class II or III pesticide, based on a scale of I to IV, I being the most toxic class.

TOXICITY

Diazinon is a moderately acutely toxic broad-spectrum insecticide, with a LD_{50} of 350 to 400 mg/kg for humans. Like other organophosphate pesticides, diazinon affects the nervous system through the inhibition of AchE, an enzyme needed for proper nervous system function. Diazinon is easily absorbed through the skin, and is synergistic with other chemicals (meaning that the two together are more toxic than either alone), including pyrethrins and certain chemicals used in pharmaceuticals.

Exposure to diazinon may cause headache, dizziness, profuse sweating, blurred vision, nervousness, nausea, vomiting, reduced heart beat, stomach cramps, diarrhea, loss of coordination, slow and weak breathing, fever, loss of consciousness, coma, uncontrollable twitching, loss of reflexes, loss of sphincter control and death. It can cause irritation to the eyes and skin, and sensitization has been reported in animal tests, though there are some questions as to whether this is due to the "inert" ingredients in tested formulations.

Repeated exposure to low doses may cause muscle twitching, anorexia, malaise, depression, irritability, confusion, anxiety, and dizziness. Damage to the pancreas has developed in some people and in laboratory animals exposed to large amounts of diazinon.

Diazinon is a mutagen. Long-term exposure may damage the developing fetus or cause birth defects, nerve damage and/or liver damage. It has been shown to cause birth defects in chick embryos (parrot beak, abnormal feathering, and development of disproportionately small limbs). These effects are thought to occur because of diazinon's ability to inhibit the synthesis of pyridine

nucleotides, and possibly also the amino acid tryptophan. A two-generation reproductive study in rats showed that diazinon exposure affected both mothers and offspring. Diazinon caused increased numbers of stillbirths and neonatal deaths in beagle dogs and birth defects in pigs.

In 1999, the Health Effects Division, Office of Prevention, Pesticides and Toxic Substances, EPA, reported "diazinon is one of the leading causes of acute reactions to insecticide use reported as poisoning incidents in the U.S." The Health Effects Division also stated that there were 11,808 unintentional residential diazinon exposures reported to Pest Control Centers from 1993-1996. EPA's now defunct Pesticide Incident Monitoring System (PIMS) reported 903 diazinon related human poisonings between 1966-1980. In the 1980's, there were 126 reports of Spectracide™ pressurized container explosions in 27 states.

ECOLOGICAL EFFECTS

Diazinon is highly toxic to bees. It has been known for some time that birds, especially grazing fowl like ducks and geese, are highly susceptible to diazinon poisoning, as are predatory or parasitic insects and mites, soil microbes, fish and aquatic invertebrates.

According to the *Prince George's Journal* diazinon caused the deaths of 14 ducks in September of 1997 in Virginia. The ducks were found dead in a small pond and sent to laboratories were Robert D. Pritchett, chief of Alexandria's Environmental Health Department stated to the *Journal* that the ducks died from "acute poisoning from the pesticide diazinon."

Diazinon has been linked to hundreds of reports of bird kills due to diazinon application on golf courses and sod farms. These reports in the 1980's involved over 23 species in at least 18 states. Diazinon poisoning also caused more than 700 Atlantic brant in New York and over 85 wigeon on a golf course in Bellingham, WA to die. Due to the large number of die offs of birds that congregated on golf courses and sod farms, EPA canceled registration of diazinon in these areas in 1988.

Although diazinon use on golf courses and sod farms has been cancelled, bird mortalities continue to occur due to exposure to diazinon used on other outdoor areas. The preliminary risk assessment released in 2000 for diazinon states that around 300 incidents of wildlife mortality, mostly birds, have been documented in the EPA, Office of Pesticide Program, Environmental Fate and Effects Division's Ecological Incidents Database (EIID), from diazinon use, which is about 10% of all ecological incidents in the database. The preliminary risk

assessment also stated that there is "a trend of steadily increasing numbers of incidents over the years."

The preliminary risk assessment for diazinon reported that the endangered species level of concern are exceeded for wildlife, aquatic life and terrestrial plants in semi-aquatic areas for all currently registered uses and application rates.

ENVIRONMENTAL FATE

In soil, degradation occurs by hydrolysis and microbial degradation, with a half-life between 14 and 80 days. Diazinon can move through the soil and contaminate groundwater. It is moderately persistent in water. Diazinon was detected in surface water in 24 states and the District of Columbia and in 54 wells in the state of California alone. The U.S. Geological Survey data show that "diazinon is the most commonly found insecticide in surface water nationally."

Residues are taken up by plants and metabolized, while some remain behind on the surface. These residues should dissipate in a few days to a week. Bacterial enzymes can speed the breakdown of diazinon in soil and have been used in treating emergency situations such as spills.

It has been reported that some forms of the compound can be degraded to more toxic forms. This transformation may occur in air, particularly in the presence of moisture, and by ultraviolet radiation.

Diazinon was one of five pesticides found to be able to concentrate in fog droplets in California agriculture areas. In April 1995, the U.S. Geological Survey began a study to determine the occurrence and temporal distribution of 49 pesticides and pesticide metabolites in air and rain samples from an urban and an agricultural sampling site in Mississippi. The study found that every rain and air sample collected from the urban and agricultural sites had detectable levels of multiple pesticides. Diazinon was found to have the highest concentration in the urban air site. It has also been found in at least 18 of the 1,430 National Priorities List (Superfund) sites identified by the EPA.

Metabolism and excretion rates for diazinon are relatively rapid. The half-life of diazinon in animals is about 12 hours. The product is passed out of the body through urine and in the feces. Cattle exposed to diazinon may store the compound in their fats for two weeks. Application of diazinon to the skin of cows resulted in trace amounts in milk 24 hours after the application.

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FENOXYCARB

USAGE

Fenoxycarb is a carbamate insect growth regulator used to control a wide variety of insect pests. It is used as a fire ant bait and for flea, mosquito, and cockroach control. It can also be used to control butterflies, moths, beetles, and scale and sucking insects on olives, vines, cotton, and fruit and on stored products, and is often formulated as a grit or corncob bait.

Fenoxycarb blocks the ability of an insect to change into the adult stage from the the juvenile stage. It also interferes with larval molting, the periodic shedding or molting of the old exoskeleton and production of a new, larger one.

TOXICITY

Fenoxycarb is a General Use Pesticide, meaning a pesticide applicator license is not required for application. EPA labels fenoxycarb as toxicity class IV and requires that the word CAUTION appear on all product labels. Based on studies in lab animals, fenoxycarb has a relatively low-toxicity. The dermal rat LD_{50} is greater than 2000 mg/kg and the oral LD_{50} is greater than 10,000. When applied directly to the skin, laboratory rats exhibited labored breathing and diarrhea. While fenoxycarb does not irritate the skin, it is an eye irritant. The liver is the primary organ affected by fenoxycarb in long-term animal studies. Fenoxycarb is a class B2 probable human carcinogen (PANNA, 2000).

Ecological Effects

Fenoxycarb is moderately to highly toxic to fish, depending on the species.

Environmental Fate

Fenoxycarb, is relatively unstable with a half-life of one day in soil and 5 hours in direct sunlight.

Compiled March 2001

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FIPRONIL

USAGE

Fipronil is a phenylpyrazole insecticide, first introduced to the U.S. in 1996 for commercial turf and animal health indoor pest control. It is a disruptor of the insect central nervous system via the GABA channel, acting with contact and stomach action. It blocks the GABA-gated chloride channels of neurons in the central nervous system, resulting in neural excitation and death of the insect (NPTN, Fipronil, 1997). It is used against cockroaches, ants, fleas, ticks, and mites (PAN, 2000). Common pesticides containing firpronil are Frontline®, Frontline® Topspot™, Combat®, and MaxForce® (NPTN, Fipronil, 1997). Concerns about human exposure to Frontline spray treatment were raised in 1996, leading to a denial of registration for the spray product (PAN, 2000).

TOXICITY

The technical form of fipronil has the signal word "Warning," implying moderate toxicity, while all formulated or end-use products in the U.S. carry the signal word "Caution," indicating low toxicity. Signs of toxicity in rats include anuria (no urination), increased excitability, seizures, and reduced feed consumption. It may cause mild irritation of the eyes and slight skin irritation, but is not a skin sensitizer (NPTN, Fipronil, 1997). It has a rat acute LD50 of 97 mg/kg, and has moderate acute toxicity by oral and inhalation routes in rats. It is of moderate dermal toxicity to rabbits, and is less toxic to mammals than to fish, some birds, and invertebrates. The photodegradate of fipronil, MB46513, is about 10 times more acutely toxic to mammals than fipronil itself (PAN, 2000).

Fipronil is neurotoxic in both rats and dogs. Severe skin reactions to Frontline Topspot for Cats and Topspot for Dogs have occurred, with skin irritation and hair loss at the site of application. Fipronil is carcinogenic to rats at doses of 300 ppm, causing thyroid cancer related to disruption in the thyroid-pituitary status, and is classified as a Group C (Possible Human) Carcinogen based on the rat carcinogenicity study (PAN, 2000). Organs affected by chronic exposure may include the liver, thyroid and kidney. Reproductive toxicity occurred at the higher doses tested, with clinical signs including reduced fertility, decreased litter size, decreased body weights in litters, and fetus mortality. There is no evidence of fipronil causing birth defects, but it may cause a delay in development at high doses (NPTN, Fipronil, 1997).

ECOLOGICAL EFFECTS

Fipronil is highly toxic to fish and aquatic invertebrates, highly toxic to bees, and highly toxic to upland game birds, but is almost non-toxic to waterfowl and other bird species. The metabolite MB 461 is more highly toxic to birds, and the metabolites MB 46136 and MB 45950 are more highly toxic to freshwater invertebrates than fipronil itself (PAN, 2000). Fipronil is excreted in rats via the feces (45-75%) and urine (5-25%) (NPTN, Fipronil, 1997).

ENVIRONMENTAL FATE

The half-life of fipronil was found to range from 122-128 days in oxygenated sandy loam soil, 0.7 to 1.7 months on soil surfaces, and 3 to 7.3 months when incorporated in soil. It has low soil mobility and little potential for groundwater contamination. In water and sediment that lack oxygen, fipronil degrades more slowly, with a half-life of 116-130 days. Its half-life in basic solutions is 28 days, and it remains stable to breakdown by water at a mildly acidic to neutral pH. When exposed to sunlight, fipronil has a half-life of 3.6 hours in water and 34 days in loamy soil (NPTN, Fipronil, 1997). The half-life on vegetation is 3-7 months. Studies showed that there is potential for bioaccumulation of the photodegradate MB 46513 in fatty tissues (PAN, 2000).

Compiled March 2001

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GLYPHOSATE

Despite widespread use of the weed killer glyphosate, and the prevalent myth that it is harmless, this pesticide is tied to acute human health effects and linked to non-Hodgkin's lymphoma. It is found in two Monsanto products, available over the counter, Roundup™ and Rodeo™, making glyphosate one of the most widely used and well-known herbicides on the market. If there is one pesticide that represents the "fast-food," quick-fix generation, glyphosate would likely be it – the McPesticide of toxic chemicals.

USAGE

Glyphosate (N-phosphono-methyl glycine), according to the Environmental Protection Agency's (EPA) most recent data on pesticide usage, was the seventh most widely used active ingredient in agriculture, with 34 to 38 million pounds used in 1997.[1] In 1995/96, glyphosate ranked as the second most used active ingredient in non-agricultural settings, with five to seven million pounds used in the home and garden and nine to twelve million pounds used in commercial settings.[2] Glyphosate use is currently growing at a rate of about 20 percent per year, due in large part to the growing number of genetically engineered crops that are resistant to the herbicide.[3] With this growth rate, it is estimated that as much as 100 million pounds of glyphosate was applied in 2000. Of course these numbers fail to reflect the poundage of inert ingredients in the formulations that are mixed with the glyphosate.

First registered for use in 1974, there are 63 glyphosate-containing pesticide formulations registered for use in the U.S. The isopropylamine salt of glyphosate, the active ingredient in 53 of these products, is used to kill a variety of broadleaf weeds and grasses. The principal agricultural uses include corn, wheat, sorghum, citrus and stone fruits, potatoes, onions, asparagus, coffee, peanuts and pineapple.[4] There are also a good number of non-food uses including ornamental, turf, forestry and rights-of-way.[5]

Some of the most widespread uses of glyphosate that have been attracting public attention include use in invasive weed management and home gardening. The increase of glyphosate use in these areas is directly tied to the larger problem of poor land management, including over grazing, over development, soil compaction and other stressors. Glyphosate has replaced ecologically sound and sustainable cultural practices such as green-mulching, and preventive maintenance such as aeration and dethatching.

Plants treated with glyphosate translocate the systemic herbicide to their roots, shoot regions and fruit, where it interferes with the plant's ability to form

aromatic amino acids necessary for protein synthesis. Treated plants generally die in two to three days. Because plants absorb glyphosate it cannot be completely removed by washing or peeling produce or by milling, baking or brewing grains. It has been shown to persist in food products for up to two years.[6]

Inert Ingredients

A letter published in the Feburary 6, 1988 *Lancet* (page 299) cited a Japanese report of 56 cases of toxic exposure to Roundup™ between June, 1984 and March, 1986. The individuals had ingested the pesticide, and experienced a range of adverse effects to their respiratory, cardovascular, and central nervous systems; nine patients died. An analysis of the findings identified one of the so-called "inert ingredients" (inerts) in the formulation, polyoxyethyleneamine (POEA), as the cause of harm. POEA is a surfactant, a chemical added to help glyphosate work its way into the plant tissue. Roundup™ contains 15% POEA.

All pesticide formulations are actually toxic soups, a mixture of the active ingredient (the registered pesticide) with a variety of other chemicals such as solvents, surfactants (like POEA), and emulsifiers – the inerts. Federal law classifies inerts as trade secrets and pesticide manufactures are not required to list inert ingredients on the pesticide label. Inerts, which can make up to as much as 99% of a pesticide formulation, are often highly toxic chemicals that can be more hazardous then the active ingredient.

Inerts known to be included in glyphosate products include ammonium sulfate, benziothiazolone, 3-iodo-2-propynl butylcarbamate (IPBC), isobutane, methyl pyrrolidinone, pelargonic acid, sodium sulfite, sorbic acid, and isopropylamine. All of these chemicals are associated with skin irritation, gastric and respiratory problems.[7]

TOXICITY

While EPA considers glyphosate to be "of relatively low oral and dermal acute toxicity,"[8] the agency does classify glyphosate in toxicity class II (class I chemicals are the most toxic in a scale from I-IV). Some glyphosate products are of higher acute toxicity, primarily due to eye and/or skin irritation.

The most recent data (1998) from California's Department of Pesticide Regulation finds that glyphosate ranks first among herbicides as the highest causes of pesticide-induced illness or injury to people in California.[9] Beyond Pesticides' own pesticide incident reporting system has received numerous reports of people poisoned by exposure to glyphosate from around the country. These

victims of pesticide exposure suffered from eye soreness, headaches, diarrhea, and other flu-like symptoms.

Symptoms following exposure to glyphosate formulations include: swollen eyes, face and joints; facial numbness; burning and/or itching skin; blisters; rapid heart rate; elevated blood pressure; chest pains, congestion; coughing; headache; and nausea.[10]

In developmental toxicity studies using pregnant rats and rabbits, glyphosate caused treatment-related effects in high dose groups, including diarrhea, decreased body weight gain, nasal discharge and death.[11]

One reproductive study using rats found kidney effects in the high dose group while another study showed digestive effects and decreased body weight gain.[12] A cancer study looking at rats found an increase in pancreas and liver tumors in males as well as an increase in thyroid cancer in females.[13]

A 1999 study, *A Case-Control Study of Non-Hodgkin Lymphoma and Exposure to Pesticides*, (American Cancer Society, 1999), found that people exposed to glyphosate are 2.7 times more likely to contract non-Hodgkin Lymphoma.

There has been controversy regarding whether glyphosate at high doses causes tumors of the thyroid and testes in rats. EPA has reported that technical glyphosate is contaminated with "less than 100 parts-per-billion" of N-nitroso-glyphosate (NNG), a by-product of synthesis. Many N-nitroso compounds are animal carcinogens. EPA is not, however, requiring further investigation of the toxicological effects of NNG, because it does not typically require data on N-nitroso contaminants present at levels of less than one part-per-million.

ECOLOGICAL EFFECTS

Glyphosate use directly impacts a variety of nontarget animals including insects, earthworms, and fish, and indirectly impacts birds and small mammals.[17] A study conducted by the International Organization for Biological Control found that exposure to Roundup™ killed over 50 percent of three species of beneficial insects – a parasitoid wasp, a lacewing and a ladybug.[18] Repeated applications of glyphosate significantly affected the growth and survival of earthworms.[19] Studies have also shown that glyphosate, and in particular the inert ingredients in the formulation of Roundup™ are acutely toxic to fish.[20]

ENVIRONMENTAL FATE

Much of the belief about glyphosate's environmental safety is based on the expectation that residues will be "immobile in soil," and therefore the chemical will not contaminate groundwater. EPA acknowledges that the material does have the potential to contaminate surface waters. If glyphosate reaches surface water, it is not broken down readily by water or sunlight.[14] The half-life of glyphosate in pond water ranges from 70 to 84 days.[15]

Glyphosate is moderately persistent in soil, with an average half-life of 47 days, although there are studies reporting field half lives of up to 174 days.[16] Residues of glyphosate have been known to persist for months in anaerobic soils deficient in microorganisms. Glyphosate residues are difficult to detect in environmental samples and most laboratories are not able to perform this service because of the lack of generally available, economically feasible methodology.

Revised and Reprinted March 2001

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2 Ibid. p. 22, Table 9.

3 Northwest Coalition for Alternatives to Pesticides. 1998. *Herbicide Factsheet: Glyphosate (Roundup)*. Journal of Pesticide Reform, vol. 18, no. 3, p. 4.

4 Environmental Protection Agency. 1993. *Glyphosate Reregistration Eligibility Decision*. p. viii.
http://www.epa.gov/REDs/old_reds/glyphosate.pdf

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HEXAFLUMURON

USAGE

Hexaflumuron is an insect growth regulator that interferes with insects' chitin synthesis. It was registered in 1994 — the first active ingredient to be registered as a "reduced risk pesticide" through the U.S. Environmental Protection Agency's (EPA's) reduced risk program, which waives tests for new pesticides that are thought to pose fewer hazards than existing pesticides. It is registered for use on termites, and is the active ingredient in the Sentricon™ bait system. It functions by inhibiting the synthesis of chitin, the material that makes up the exoskeleton of insects (Cox, 1997).

TOXICITY

Hexaflumuron has a low toxicity to rats when ingested, with a LD_{50} >5000mg/kg for male and female rats. Based in its low LD_{50} in laboratory animals, it is assumed to be of low toxicity to humans. It is a mild skin and eye irritant, and is not expected to cause carcinogenic, mutagenic, or teratogenic effects (NPTN, Hexaflumeron, 2000). In chronic feeding studies, hexaflumuron increased the incidence and severity of liver cell abnormality. Because it was registered as a reduced-risk pesticide, many of the standard tests are lacking for hexaflumuron, including subchronic toxicity testing, delayed neurotoxicity testing, and tests for developmental or reproductive effects (Cox, 1997).

ECOLOGICAL EFFECTS

It is highly toxic to aquatic animals and should not be used in areas where it could be washed out of the bait station into water at or near the ground surface (MSDS, Recruit II). Hexaflumuron may cause long-term effects in the aquatic environment, and will lead to bioaccumulation of the chemical in fish. It has a very low toxicity to birds (ILO, ISCS: 1266, 1995).

ENVIRONMENTAL FATE

Studies have found the half-life of hexaflumuron to range from 40-160 days. It has low mobility in soil, binding strongly to soil particles, and is not highly soluble in water. If used according to the manufacturer's specifications, it is not likely to contaminate surface or groundwater(NPTN, Hexaflumuron, 2000).

Compiled March 2001

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National Pesticide Telecommunication Network. 2000. *Hexaflumuron Technical Fact Sheet*. July 18.Oregon State University. Corvallis, OR.

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HORTICULTURE OILS, PETROLEUM BASED

USAGE

Oils are hydrocarbons used as contact insecticides, acaricides, and ovicides. Kerosene was the first petroleum oil to be used for insect control in the early 1900's. Most horticulture oils used today are petroleum based (Grossman 1990), yet a growing number of horticulture oils are being made with vegetable oils, which are considered a least toxic pesticide. *Carefully read the label or ask your pest control service provider to determine if the horticulture oil is vegetable or petroleum based.*

Horticulture oils are effective in controlling aphids, adelgids, spider mites, mealy bugs, sawfly larvae, whiteflies, plant bugs, caterpillars, scales, and some plant diseases like rusts and mildews (Olkowski 1991). They flood insects breathing pores which lead to prompt asphyxiation and suffocation. Oils also kills an insect when it touches the outer body, or cuticle, of an insect leading to dehydration and death of the pest.

Horticulture oil sprays are formulated with a detergent or soap surfactant in order to keep the product from separating. Adding soaps to horticulture oil products also increase the effectiveness of its insecticidal properties. There are several types of formulations of oils: dormant oils, summer oils, emulsifiable oils and stock emulsions. Dormant oils are extremely phytotoxic with varying degrees of susceptibility between varieties and species. Dormant oils tend to contain a higher level of impurities, but modern refining techniques have removed a high percentage of phytotoxic impurities (Grossman 1990).

Horticulture oils have not been found to lead to insect resistance (Thomson 1983).

TOXICITY

Because of horticulture oils mode of action, they do not pose the high exposure risk that chemical pesticides do. Horticulture oils have relatively low mammalian toxicity (Grossman 1990). Petroleum based horticulture oils can cause skin and eye irritation (Olkowski 1991).

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HYDRAMETHYLNON

USAGE

Hydramethylnon (Amdro™, Maxforce™, Siege™) is a trifluoromethyl aminohydrazone, a metabolic inhibitor, used mainly in granular baits or ready-to-use gelatin baits to control ants, cockroaches, crickets and termites (U.S. EPA 1998). The chemical is listed in toxicity category III by EPA (on a scale of I to IV, I being the highest toxicity rating), requiring any products to have the signal word CAUTION printed on the label due to eye irritation (EXTOXNET 1996).

Hydramethylnon works as a metabolic inhibitor by blocking the biological process in the insect that makes Adenosine Triphosphate (ATP). ATP is a compound required by most biological processes to provide energy for life. Without ATP, the target pest becomes lethargic and stops eating. Death usually occurs within 24 to 72 hours, although the speed of the product depends on temperature and target insect activity.

TOXICITY

LD_{50} (lethal dose for 50% of the test population) values have shown hydramethylnon to be slightly toxic through ingestion (1100 to 1300 mg/kg) in rats and through skin exposure (5000 mg/kg) in rabbits. Acute exposure can cause irritation to the eyes and mucous membranes lining the respiratory tract (EXTOXNET 1996).

EPA has classified hydramethylnon as a 'Group C' carcinogen, or possible human carcinogen. Studies in both rats and dogs have shown decreased food consumption, while a 2-year rat study showed increased liver weights and increased liver to body ratios (U.S. EPA 1995). Chronic studies done on hydramethylnon have shown the testis to be a target organ of the pesticide. Mice fed doses of approximately 3.8 mg/kg/day for 18 months developed testicular lesions, while studies in both rats and dogs have resulted in testicular atrophy. In a study of potential birth defects in rabbits, doses of 10 mg/kg/day resulted in reduced fetal weights.

ECOLOGICAL EFFECTS

Hydramethylnon is highly toxic to fish in laboratory settings. The 96 hour LC_{50} (lethal concentration to 50% of the test population) is 0.16 mg/L in rainbow trout, 0.10 mg/L in channel catfish and 1.70 mg/L in the bluegill sunfish (Kidd 1991). Low to moderate capacity to accumulate in biological tissue was demonstrated

when hydramethylnon accumulated in bluegill sunfish at 1300 times its concentration in surrounding waters (ETN 1996).

ENVIRONMENTAL FATE

Soil half-life for hydramethylnon is estimated at around ten days. Breakdown seems to be enhanced by light and soil organisms. Its low solubility in water and strong absorption by soil organic matter give it low mobility through the soil. This also decreases its likelihood to contaminate groundwater. The reported half-life for hydramethylnon in water is 10 to 11 days over a pH range of 7 to 8.9 and 24 to 33 days at a pH of 4.9 (ETN 1996).

Compiled March 2001

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IMIDACLOPRID

USAGE

Imidacloprid is a systemic, chloro-nicotinyl insecticide used for the control of sucking insects such as fleas, aphids, whiteflies, termites, turf insects, soil insects, and some beetles. It has not been fully evaluated for human health and environmental effects.

It causes a blockage in a type of neural pathway that is more abundant in insects than in warm-blooded animals, leading to an accumulation of acetylcholine, a neurotransmitter, and resulting in the insect's paralysis and eventual death. It is effective on contact and via stomach action.

TOXICITY

Imidacloprid is classified by the Environmental Protection Agency (EPA) as both a toxicity class II and class III pesticide (on a scale of I to IV, I being the highest toxicity class), and must be labeled with the signal word "Warning" or "Caution." Symptoms of acute exposure are expected to be fatigue, twitching, cramps, and muscle weakness including the muscles necessary for breathing. The LD_{50} is 450 mg/kg body weight in rats and 131 mg/kg in mice. The 24-hour dermal LD_{50} in rats is >5,000 mg/kg. The airborne concentration that resulted in mortality to half of the test organisms (LC50) is >69 mg/meters cubed air in the form of an aerosol, and >5323 mg/meters cubed in air in the form of dust. It is considered non-irritating to eyes and skin, and non-sensitizing to skin, though some granular formulations may contain clay as an inert ingredient, which may act as an eye irritant.

In a study of rats fed up to 1,800 parts per million (ppm), the NOEL (No Observable Effect Level) was found to be 100 ppm, with adverse effects including decreased body weight gain in females at 900 ppm and 300 ppm in males. A study of dogs fed up to 2,500 ppm resulted in a NOEL of 1,250 ppm, with adverse effects including some stress to the liver and increased blood cholesterol levels. A reproduction study in rats fed up to 700 ppm resulted in a NOEL of 100 ppm based on decreased pup body weight observed at the 250-ppm dose level. A developmental toxicity study in rats given doses up to 100 ppm during days 6 to 16 of gestation resulted in a NOEL of 30 mg/kg/day based on skeletal abnormalities observed at the next highest dose tested. Another developmental toxicity study with rabbits given doses of imidacloprid during days 6 through 19 of gestation resulted in a NOEL of 24 mg/kg/day based on decreased body weight and skeletal abnormalities at the highest dose tested.

Imidacloprid was found to be weakly mutagenic, testing positive for causing changes in human lymphocyte chromosomes and for genotoxicity in Chinese hamster ovary cells. It categorized as a "Group E" carcinogen (evidence of noncarcinogenicity for humans) by EPA. In feeding studies in rats, very high doses of imidacloprid were associated with thyroid lesions.

Imidacloprid is quickly and nearly completely absorbed from the gastrointestinal tract and eliminated in urine and feces. Imidacloprid can be phytotoxic when not used according to the manufacturer's specifications.

ECOLOGICAL EFFECTS

It is considered toxic to upland game and birds, of moderately low toxicity to fish, and highly toxic to bees if used as a foliar application, especially during flowering.

ENVIRONMENTAL FATE

In soil, Imidacloprid has a half-life of 48-190 days, breaking down more quickly in soils with plant ground cover. It degrades into the primary metabolite 6-chloronicotinic acid, which eventually breaks down into carbon dioxide. There is low risk for groundwater contamination, it is moderately soluble, and has moderate binding affinity to organic materials in soil. The half-life in water is myth greater than 31 days at a pH of 5, 7, and 9.

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Extension Toxicology Network (ETN). 1995. Pesticide Information Profiles: Imidacloprid. < http://ace.orst.edu/cgi-in/mfs/01/pips/imidaclo.htm>.

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LINDANE

USAGE

Lindane, like DDT and in the organochlorine family, has been controversial for decades because of its cancer causing and neurotoxic properties. Despite its toxicity, lindane is commonly prescribed as a pharmaceutical to treat lice and scabies, and is used as a seed treatment.

While the U.S. Environmental Protection Agency (EPA) regulates pesticide use, it is the Food and Drug Administration (FDA) that regulates medicinal use of lindane to treat lice and scabies. Over 2 million lindane prescriptions for head lice and scabies are issued every year. (NPA, 2000)

Over the past ten years, all uses of lindane have been voluntarily canceled by lindane registrants, except 13 seed treatment uses and prescription-only treatments for lice and scabies, (Howard, 2000). Despite this, FDA residue monitoring in 1999 found lindane to be the 12th most commonly found pesticide residue in food samples tested (FDA, 1999).

Lindane Bans
In September 2000, California Governor Davis signed a bill that prohibits the use or sale of any lindane containing products for treatment of human head lice or scabies by January 1, 2002.

At least 14 countries have banned all uses of lindane and 16 countries have severely restricted its use. In July 2000, the European Union's Standing Committee on Plant Health voted to ban all agricultural and gardening applications of lindane. The European Commission is expected to ratify the decision, which should come into effect by 2002 (Schafer, 2000).

Routes of Exposure
Exposure to lindane is a concern, especially considering its inclusion in creams and shampoos for lice and scabies. Lindane is efficiently absorbed across the skin, with a documented 9.3% dermal absorption rate. It is absorbed even more efficiently across abraded skin, which is of high concern considering the severe dermatitis associated with scabies. Absorption across the skin as well as in the gut is enhanced by the presence of fat and fat solvents. Although lindane is not highly volatile, pesticide-laden aerosol or dust particles trapped in respiratory mucous and subsequently swallowed may lead to significant absorption in the gut (Reigart, 1999). Following absorption, lindane is partially dechlorinated and oxidized, promptly yielding a series of conjugated chlorophenols and other oxidation products in the urine. Excretion of lindane occurs within a few days,

primarily through the feces. While exposure to most organochlorines results in significant storage of the unchanged parent compound in fat tissue, the rapid metabolic breakdown of lindane reduces the likelihood that it will be detected in body fat, blood or milk (Reigart, 1999).

TOXICITY

EPA classifies lindane as moderately toxic, or a class II, chemical and bears the signal word "warning." The chief toxic action is on the nervous system where lindane, like other organochlorines, interferes with the flux of cations across nerve cell membranes. Adverse health effects include: apprehension, agitation, mental/motor impairment, excitation vomiting, stomach upset, abdominal pain, central nervous system depression, convulsions, muscle weakness and spasm, loss of balance, grinding of the teeth, hyper-irritability, violent seizures, increased respiratory rate and/or failure, dermatitis, immunotoxicity, and fetotoxicity.

Lindane is more acutely toxic than DDT and may modify brain function for days and even weeks after a single exposure (Gosselin, 1983). Data from animal tests indicate that lindane may affect the liver, kidney, pancreas, testes, and nasal mucous membrane (Dalsenter, 1997; Sircar, 1989; ETN, 1996, US EPA, 1985; US EPA, 1998). Lindane is an endocrine disruptor and was found to be slightly estrogenic to female rats and mice, and caused the testes of male rats to become atrophied (PAN, 1998; ETN, 1996). Lindane has been shown to induce drug-metabolizing enzymes in the liver (Gosselin, 1983). This tends to accelerate excretion of the pesticides themselves, but may also stimulate biotransformation of critical natural substances, such as steroid hormones and therapeutic drugs (Reigart, 1999).

Diet and age can affect sensitivity to lindane's toxic action. Children are more sensitive, doses of 1.6 and 45 grams are capable of producing seizures in young children and adults, respectively. A low protein diet may render an individual more susceptible as well. Rats on low protein diets were twice as susceptible to the acute toxic effects of lindane compared with animals on a normal diet (Gosselin, 1983).

There is a great deal of anecdotal evidence in medical literature linking chronic lindane exposure to rare blood disorders including aplastic anemia (West, 1967; PAN, 1998). Pulmonary edema has been reported after intentional lindane ingestion (US EPA, 1998), but the exact role of aspiration in producing these changes is not clear. The development of myoglobin in the urine, acute kidney failure, and muscle weakness in the limbs after ingestion of 15-20 ml of lindane suggests that it may be a direct muscle toxin (Gosselin, 1983).

A laboratory study found that a single topical application of 1% lindane on weanling rabbits caused convulsions. Gosselin et al. report six human cases of alleged neurotoxicity associated with the use of this type of product. At least five of these were judged the result of accidental ingestion or inappropriate application. "Some children exhibited seizures after total body applications or after applications that were left on longer than the recommended 24 hours."

Carcinogenicity

The International Agency for Research on Cancer (IARC) has concluded that lindane is a possible human carcinogen (class 2B), and EPA has classified it similarly as a class B2/C possible human carcinogen based on liver and lung tumors in mice (US EPA, 2000a). The State of California has listed lindane as known carcinogen (CalEPA, 1999).

Lindane is linked to breast cancer (Wolff, 1985; Schafer, 2000). There is a significant body of evidence that suggests that where lindane is used extensively, and particularly in areas where cattle were treated, the incidence of breast cancer is elevated (PAN, 1998). The presence of lindane in human and cow milk has been reported in countries throughout the world (Moses, 1993; Schafer, 2000).

Regulatory History

In 1977, lindane was put into EPA Special Review because of concerns over its ability to cause cancer, fetotoxicity/teratogenicity, reproductive effects, blood dyscrasia, and its acute toxicity to aquatic wildlife. In 1980, EPA proposed canceling most uses of lindane because "lindane continues to meet or exceed the risk criteria for oncogenicity and reproductive and fetotoxic effects," noting children's particular risk (US EPA, 1980). However, in its final 1983 decision, EPA continued most registrations with various restrictions. At the time, the Scientific Advisory Panel supported bans on household, pet and homeowner ornamental applications (US EPA, 1983). In 1985, lindane again came under EPA scrutiny because of its link with kidney effects (US EPA, 1985). Over the past 10 years, most uses, including wood treatment, foliar, termiticide, home insecticidal and military use of lindane, have been voluntarily canceled by the chemical's registrants (Howard, 2000).

In 1996, FDA's Dermatologic Drugs Advisory Committee reviewed claims that lindane causes neurological damage in children and required additional advisories on packaging, and a warning against repeated treatment with lindane products, because repeated treatments have been clearly linked to neurotoxicity. FDA stated, "The reason for the product's misuse may be connected with pruritus - itching that continues after ... treatment - due to the residual inflammation in the skin. When treated children continue to scratch, some parents may continue to medicate beyond the recommended procedure" (Kupec, 1996).

Currently, EPA is working on the preliminary risk assessment for lindane as required under the *Federal Insecticide, Fungicide and Rodenticide Act* and the *Food Quality Protection Act* (Howard, 2000). Lindane's preliminary risk assessment and registration eligibility is expected to be released for public comment period in 2001, at which time registered uses will be reviewed and decisions on continued registration for each use will be made (US EPA, 2000b).

ECOLOGICAL EFFECTS

Lindane is moderately toxic to bird species and can be stored in the fat of birds. Residues can also find their way into egg yolks at measurable concentrations for 32 days after dosing. Lindane is highly toxic to fish and aquatic invertebrate species. Lindane is also highly toxic to bees and certain beneficial parasites and predacious insects (ETN, 1996; US EPA, 1994).

Plants may pick up residues from not only direct application, but through water and vapor phases. Persistence is seen when plants are rich in lipid content, and crops like cauliflower and spinach will build up less residue than crops like carrots (ETN, 1996).

ENVIRONMENTAL FATE

Lindane is highly persistent in most soils, with a field half-life of approximately 15 months. It may be mobile in soils and may pose a risk of groundwater contamination. Lindane is very stable in both fresh and salt water and is resistant to photodegradation (ETN, 1996). EPA's Office of Water established the maximum contaminant level for lindane in drinking water at 0.2 parts per billion (US EPA, 1998). From 1987 to 1993, according to EPA's Toxics Release Inventory, lindane releases to land and water totaled 1,115 pounds (US EPA, 1998). Lindane has been found in 239 sites listed on EPA's National Priorities List (ATSDR, 1995).

Resistance

The Centers for Disease Control and Prevention, and the World Health Organization, among others, cite widespread insect resistance to lindane in the U.S. and other parts of the world (NPA, 2000; Downs, 1999; Brainerd, 1998).

Updated October 2000

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METHOPRENE

USAGE

Methoprene, an insect growth regulator, is being applied to many home and community pest control problems as a general use, slow-acting insecticide. This chemical can be used to control a number of pests, including fleas (Precor™), mosquitoes (AltosidTM), pharaoh ants, leaf miners and hoppers, and cucmber beetles. It is also used as an insect control in food production and agriculture (U.S. EPA 1991). EPA estimated in 1982 that 57% of use at that time was as an additive to cattle feed and mineral supplements to control horn flies.

This chemical is an analog to a unique insect-growth regulating hormone, which does not ressemble any known mammalian hormones. Use requires careful attention to timing and patience. Applied at very low rates, while insect populations are still in the egg or larval stage of their life cycle, methoprene prevents development to the adult reproductive stages so that insects die in arrested immaturity. Methoprene is not toxic when applied to adult stages of the target insect. Because the chemical interferes with the insect's normal life cycle and is not directly toxic to the pest, it is considered to be a biochemical pesticide (EXTOXNET 2001).

TOXICITY

According to information contained in a 1982 EPA Registration Standard, methoprene is of extremely low acute toxicity to mammals (LD50 equals 36,500 mg/kg). It is not a skin or eye irritant, although it is slightly toxic via dermal absorbtion. For this effect, methoprene is a toxicity category III with the signal word CAUTION required on the label (U.S. EPA 1991).

No adverse effects have been reported in animal bio-assays for long-term health effects and short-term tests for mutagenicity were all negative. EPA reviewers found that animals rapidly metabolize and excrete the material, the major non-water soluble metabolite in animal assays being cholesterol.

Ecological Effects

Methoprene may have severe developmental effects on frogs. It was found to be a possible cause of a sharp rise in the incidence of frog deformities throughout North America. A 1997 study linked pesticides to frog deformities when they found a higher number of hindlimb frog deformities occurring in agricultural areas (Oulette 1997).

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It is believed that a breakdown product of methoprene mimics retinoic acid, an important chemical to the development of fish and frog embryos. Laboratory tests involving raised levels of retinoic acid have resulted in a majority of the limb deformities found in the North American frogs (Conlan 1996).

Methoprene also has a moderate toxicity towards both warm and cold water, freshwater fish, although exposure of these organisms is limited due to methoprene's rapid degradation in unshaded water. It is highly acutely toxic to estuarine and marine invertebrates, which play an important role in the delicate estuarine ecosystem. The LC_{50} (concentration needed to kill half of the test population) for fresh water shrimp is greater than 0.1 ppb (parts per billion) and the LC_{50} for the estuarine mud crabs is greater than .0001 ppb. Meanwhile, the level of methoprene released into an environment from a general application is expected to be around 10 ppb (EXTOXNET 2001).

ENVIRONMENTAL FATE

Studies reviewed by EPA indicate that if protected from light, methoprene is quite stable in water within the pH range 5-9, not degrading after 30 days in the dark. The BioIntegral Research Center of Berkeley, CA reports that methoprene used inside homes is active for at least 6 months against developing fleas. When exposed to light, however, methoprene degrades within 7 days to more than 50 products, not all of which have been identified.

The chemical's soil half-life is between 10-14 days in four soils tested, where it is microbially degraded to carbon dioxide and soil-bound products.

Although the mode of action and low persistence of methoprene imply that resistance problems should be slow to develop, resistance to insect growth hormones has been induced experimentally and therefore might be possible in the field.

Data Gaps

A Reregistration Eligibility Document has been created for methoprene and most products were accepted for reregistration for use in the United States. However, the U.S. EPA is still requiring an estuarine invertebrate life cycle study in order to determine adverse effects of methoprene on those species from long term exposures to briquette formulations of the pesticide (EXTOXNET 2001).

Compiled March 2001

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PIPERONYL BUTOXIDE (PBO)

USAGE

Piperonyl butoxide, or PBO, is a pesticide synergist. A synergist is another chemical that is added to a pesticide product, in addition to the active and inert ingredients, to increase the potency of the active ingredient. While the increased potency make the pesticides more deadly to their targets, synergists may also compromise the detoxifying mechanisms of non-target species, including humans. A typical pesticide product contains 5-20 times more synergist than active ingredient. Many products from repellants and pediculicides (lice killers) to foggers and garden sprays contain synergists. Formulations of permethrin, resmethrin and sumithrin, including Scourge™ and Anvil™, used along the for mosquito control to combat the West Nile Virus, commonly contain the synergist PBO. Prethroids, pyrethrins, rotenone and carbamates are the pesticides most often formulated in combination with PBO (Gosselin et al., 1984).

TOXICITY

PBO affects humans by inhibiting important liver enzymes responsible for breakdown of some toxins, including the active ingredients of pesticides. Specifically, it has been shown to inhibit hepatic microsomal oxidase enzymes in laboratory rodents and interfere in humans. Because these enzymes act to detoxify many drugs and other chemicals, a heavy exposure to an insecticidal synergist may make a person temporarily vulnerable to a variety of toxic insults that would normally be easily tolerated (Gosselin et al., 1984). In addition to the symptoms induced by the active ingredients, signs of PBO poisoning include anorexia, vomiting, diarrhea, intestinal inflammation, pulmonary hemorrhage and perhaps mild central nervous system depression. Repeated contact may cause slight skin irritation. Chronic toxicity studies have shown increased liver weights, even at the lowest doses, 30 mg/kg/day. Animal studies have shown hepatocellular carcinomas, even treatments as low as 1.2% (Takahashi et al., 1994). EPA considers PBO to be a class C possible human carcinogen.

ECOLOGICAL EFFECTS

PBO is moderately toxic to most amphibians, crustaceans, fish and other aquatic organisms. However, study published by the U.S. Fish and Wildlife Service found piperonyl butoxide to be very highly toxic to bluegills and aquatic sowbugs (Johnson, 1980).

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ENVIRONMENTAL FATE

Very little is known about the persistence of PBO in the environment.

Revised August 1990

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PROPETAMPHOS

USAGE

Propetamphos in an organophosphate insecticide used for the control of roaches, ants, fleas, ticks, moths, mosquitoes, and termites either indoors or in vector eradication programs to protect public health. In veterinary applications, it is used to combat parasites, including ticks, lice and mites in livestock. Its total annual usage is estimated to be 90,000 pounds active ingredient (U.S. EPA, 2000). Propetamphos is in U.S. Environmental Protection Agency (EPA) toxicity class II, moderately toxic and labels must carry the signal word "Warning."

TOXICITY

Orally, propetamphos is considered moderately toxic, with a LD50 75-119 mg/kg in rats. It is slightly toxic dermally, with LD50 values of 2,300 to greater than 3,100 mg/kg in rats, and greater than 10,000 mg/kg in rabbits. It is slightly toxic via inhalation. Acute exposure can cause nausea, numbness, tingling, incoordination, headache, tremor, dizziness, confusion, abdominal cramps, sweating, blurred vision, respiratory paralysis, neurological and neuromuscular effects, and death due to cholinesterase inhibition (ETN, 1996).

Studies have shown that propetamphos does not cause reproductive toxicity, is not teratogenic, is weakly or nonmutagenic, and is noncarcinogenic. The primary target organ affected by propetamphos is the nervous system (ETN, 1996).

ECOLOGICAL EFFECTS

Propetamphos is moderately toxic to birds, and highly toxic to fish and aquatic invertebrates (ETN, 1996).

ENVIRONMENTAL FATE

There are no data available concerning the breakdown of propetamphos in soil, groundwater, or vegetation. It is rapidly degraded in water only under extreme pH conditions or in the presence of sunlight (ETN, 1996).

Compiled March 2001

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U.S. EPA. 2000. *Reregistration Eligibility Document: Propetamphos*. Office of Pesticide Programs. Washington D.C.

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ECOLOGICAL EFFECTS

EPA found sulfur to be of low toxicity to bees, aquatic organisms, birds, and fish.

ENVIRONMENTAL FATE

The Agency is not requiring submission of residue chemistry data, given sulfur's ubiquity in the environment, and has also waived environmental fate testing, including aquatic soil and water testing. Soil bacteria convert the insoluble element into the sulfate ion, which is water-soluble and can slowly leach into water.

Revised March 1988

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SYNTHETIC PYRETHROIDS

Pesticide products containing pyrethroids are often described by pest control operators and community mosquito management bureaus as "safe as chrysanthemum flowers." While pyrethroids are a synthetic version of an extract from the chyrsanthemum, they were chemically designed to be more toxic with longer breakdown times, and are often formulated with synergists, increasing potency and compromising the human body's ability to detoxify the pesticide.

USAGE

Synthetic pyrethroids are synthesized derivatives of naturally occurring pyrethrins, which are taken from pyrethrum, the oleoresin extract of dried chrysanthemum flowers. The insecticidal properties of pyrethrins are derived from ketoalcoholic esters of chrysanthemic and pyrethroic acids. These acids are strongly lipophilic and rapidly penetrate many insects and paralyze their nervous system (Reigart et al., 1999). Both pyrethrins and synthetic pyrethroids are sold as commercial pesticides used to control pest insects in agriculture, homes, communities, restaurants, hospitals, schools, and as a topical head lice treatment. Various formulations of these pesticides are often combined with other chemicals, known as synergists, to increase potency and persistence in the environment.

While chemically and toxicologically similar, pyrethrins are extremely sensitive to light, heat and moisture. In direct sunlight, half-lives that can be measured in hours. However, the pyrethroids, the synthetic analogues of naturally occurring pesticides, were developed to capture the effective insecticidal activity of this botanical insecticide, with increased stability in light, yielding longer residence times (Gosselin et al., 1984).

TOXICITY

Pyrethroids have irritant and/or sensitizing properties. They are not easily absorbed through the skin, but are absorbed through the gut and pulmonary membrane. Tests of some pyrethroids on laboratory animals reveal striking neurotoxicity when administered by injection or orally. Systemic toxicity by inhalation and dermal absorption is low. The acute toxicity, calculated by LD_{50}'s, ranges from low to high, depending on the specific formulation. Low toxicity is attributed to two factors: limited absorption of some pyrethroids, and rapid biodegradation by mammalian liver enzymes (ester hydrolysis and oxidation). Insects, without this liver function, exhibit greater susceptibility to the chemicals (Reigart et al., 1999).

Pyrethroids interfere with the ionic conductance of nerve membranes by prolonging the sodium current. This stimulates nerves to discharge repeatedly causing hyper-excitability in poisoned animals. The World Health Organization explains that synthetic pyrethroids are neuropoisons acting on the axons in the peripheral and central nervous systems by interacting with sodium channels in mammals and/or insects. The main systems for metabolism include breakage of the ester bond by esterase action and oxidation at various parts of the molecule. Induction of liver microsomal enzymes has also been observed (WHO, 1999).

Signs and symptoms of poisoning by pyrethroids may take several forms. Because of the similarities to crude pyrethrum, pyrethroids may act as dermal and respiratory allergens. Exposure to pyrethroids has resulted in contact dermatitis and asthma-like reactions. Persons, especially children, with a history of allergies or asthma are particularly sensitive, and a strong cross-reactivity with ragweed pollen has been recognized. Severe anaphylactic (allergic) reactions with peripheral vascular collapse and respiratory difficulty are rare. Other symptoms of acute toxicity due to inhalation include sneezing, nasal stuffiness, headache, nausea, incoordination, tremors, convulsions, facial flushing and swelling, and burning and itching sensations. The most severe poisonings have been reported in infants, who are not able to efficiently break down pyrethroids (ETN, Pyrethroids, 1994). With orally ingested doses, nervous symptoms may occur, which include excitation and convulsions leading to paralysis, accompanied by muscular fibrillation and diarrhea (ETN, Pyrethroids, 1994). Death in these cases is due to respiratory failure. Symptoms of acute exposure last about 2 days.

Endocrine Disruption and Breast Cancer

Many pyrethroids have also been linked to disruption of the endocrine system, which can adversely affect reproduction and sexual development, interfere with the immune system and increase chances of breast cancer. Pyrethroids contain human-made, or xenoestrogens, which can increase the amount of estrogen in the body (Garey et al., 1998). When tested, certain pyrethroids demonstrate significant estrogenicity and increase the levels of estrogen in breast cancer cells (Go et al., 1999). Because increased cell division enhances the chances for the formation of a malignant tumor in the breast, artificial hormones, like those found in pyrethroids, may increase breast cancer risk (PCBR, 1996). Some pyrethroids are classified by EPA as possible human carcinogens.

ECOLOGICAL EFFECTS

While the development of the synthetic pyrethroids was heralded with claims of selective toxicity to insects, both pyrethroids and pyrethrins are extremely toxic

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to aquatic organisms, including fish such as the bluegill and lake trout, with LC_{50} values less than 1.0 parts per billion. These levels are similar to those for mosquito, blackfly and tsetse fly larvae, often the actual target of the pyrethroid application. Lobster, shrimp, mayfly nymphs and zooplankton are the most susceptible non-target aquatic organisms (Mueller-Beilschmidt, 1990). The nonlethal effects of pyrethroids on fish include damage to the gills and behavioral changes.

Pyrethroids are moderately toxic to birds, with most LD_{50} values greater than 1000 mg/kg. Birds can also be indirectly affected by pyrethroids, because of the threat to their food supply. Waterfowl and small insectivorous birds are the most susceptible (Mueller-Beilschmidt, 1990). Because pyrethroids are toxic to all insects, both beneficial insects and pests are affected by pyrethroid applications. In some cases, predator insects may be susceptible to a lower dose than the pest, disrupting the predator-prey relationship.

ENVIRONMENTAL FATE

As mentioned before, pyrethroids are designed to breakdown more slowly than the naturally occurring pyrethrins. While pyrethrins, extremely sensitive to light, heat and moisture, break down in a few hours, the synthetic pyrethroids are stable and persist in the environment much longer. As a general rule, pyrethroids break down most quickly in direct sunlight, usually just a few days after application, with a few exceptions. However, in areas with limited sunlight, such as grain silos and subway tunnels, pyrethroids can persist for months. For more specific breakdown times see the sections below on resmethrin, permethrin and sumithrin.

Synergists

Both pyrethroids and pyrethrins are often formulated with oils or petroleum distillates and packaged in combination with synergists, such as piperonyl butoxide (PBO) and n-octyl bicycloheptene dicarboximide (Gosselin et al., 1984). Synergists are added to increase the potency of the pesticide. A range of products from repellants to foggers to pediculicides (lice killers) to garden sprays contain synergists. Many formulations of permethrin, resmethrin and sumithrin, including Scourge™ and Anvil™, used along the East Coast for mosquito control to combat the West Nile Virus, contain the synergist PBO.

PBO inhibits important liver enzymes responsible for breakdown of some toxins, including the active ingredients of pesticides. Specifically, it has been shown to inhibit hepatic microsomal oxidase enzymes in laboratory rodents and interfere in humans. Because these enzymes act to detoxify many drugs and other

chemicals, a heavy exposure to an insecticidal synergist may make a person temporarily vulnerable to a variety of toxic insults that would normally be easily tolerated. Symptoms of PBO poisoning include anorexia, vomiting, diarrhea, intestinal inflammation, pulmonary hemorrhage and perhaps mild central nervous system depression. Repeated contact may cause slight skin irritation. Chronic toxicity studies have shown increased liver weights, even at the lowest doses, 30 mg/kg/day. While not considered a carcinogen by EPA, animal studies have shown hepatocellular carcinomas, even treatments as low as 1.2% (Takahashi et al., 1994).

PERMETHRIN
(Pounce™, Torpedo™, Dragnet™)

Prior to 1978, permethrin was registered for use on cotton crops only. During the early 1980's registration was expanded to include use on livestock and poultry, eggs, vegetables and fruit. Today uses also include lice treatments and urban/suburban pest control. Permethrin resembles pyrethrins chemically, but is chlorinated to increase its stability. There are four isomeric forms, two cis and two trans of technical permethrin. Although the acute toxicity of the mixture (oral rat LD_{50} > 5000 mg/kg, oral mouse LD_{50} = 500) is less than that of natural pyrethrins, the cis-isomer is considerably more toxic (oral mouse LD_{50} = 100), and in rats, the metabolites of the cis-isomer are more persistent biologically. (The cis and trans isomers differ in the spatial arrangement of the atoms.) Formulations of permethrin can vary greatly in isomeric content. Compared to other pyrethroids, permethrin is very stable, even when exposed to ultraviolet light. Permethrin is strongly absorbed to soil and other organic particles, with half-lives in soil of up to 43 days. When used as a termiticide, permethrin can persist up to 5 years.

Permethrin receives an EPA toxicity class rating of II or III, (I = most toxic, IV = least toxic) and carries either the word WARNING or CAUTION on its label, depending on the formulation. While it is not extremely toxic to humans, there are numerous reports of transient skin, eye and respiratory irritation. Like all pyrethroids, permethrin is a central nervous system poison. Workers and researchers report tingling in face and hands, and some report allergic reactions. Based on studies demonstrating carcinogenicity, EPA ranks permethrin as a class C, or possible human carcinogen (U.S. EPA, 1997). Other studies have shown effects on the immune system, enlarged livers and at high doses, decreased female fertility. Permethrin is extremely toxic to aquatic life, bees and other wildlife. It should not be applied in crops or weeds where foraging may occur (ETN, Permethrin, 1996).

RESMETHRIN
(Scourge™, Raid Flying Insect Killer™)

Resmethrin is used for control of flying and crawling insects in homes, greenhouses, processing plants, commercial kitchens, airplanes and for public mosquito control. Resmethrin is considered slightly toxic to humans and is rated EPA toxicity class III, bearing the word CAUTION on its label. The oral rat LD_{50} is about 2500 mg/kg. Although resmethrin has a very short half-life (under an hour in direct sunlight), it persists much longer in soil with a half-life of 30 days (ETN, Resmethrin, 1996). Resmethrin breaks down into a smelly byproduct, phenylacetic acid, which binds strongly to textiles and dissipates slowly, smelling of urine.

Resmethrin is absorbed rapidly and distributed to all tissues including the brain. Skin absorption is low, although it should be noted that some individuals manifest allergic responses including dermatitis, asthma, runny nose and watery eyes after initial contact. In laboratory animals, chronic toxicity studies have shown hypertrophy of the liver, proliferative hyperplasia and benign and cancerous liver tumors. EPA reviewers noted slight, but significant, increases in the number of offspring born dead and decreased viability, which they thought might be secondary to trans placental toxicity. Tests for neurotoxicity have been negative. Resmethrin is extremely toxic to fish, other aquatic life and bees. The domestic manufacturer of resmethrin, Penick Company, will not identify the inert ingredients in its product, but recommends that it is not sprayed on paint, plastic or varnished surfaces, and that treatment of living areas or areas with large amounts of textiles be avoided.

SUMITHRIN
(Anvil™, d-Phenothrin)

Sumithrin has been registered for use since 1975. It is used to control adult mosquitoes and as an insecticide in transport vehicles, commercial, industrial and institutional non-food areas, in homes, gardens, greenhouses and on pets. Chemically, it is an ester of chrysanthemic acid and alcohol. It is a combination of two cis and two trans isomers. Sumithrin is slightly toxic and is rated EPA toxicity class IV bearing the word CAUTION on its label. The oral rat LD_{50} is greater than 5,000 mg/kg, and the LC_{50} for inhalation is greater than 1210 mg/m^3. Sumithrin degrades rapidly, with a half-life of 1-2 days under dry, sunny conditions. Under flooded conditions, the half-life increases to 2-4 weeks for the trans isomer and 1-2 months for the cis isomer. In grain silos, with no sunlight and little air circulation, most of the product still remains after one year (WHO, 1990).
Symptoms of acute sumithrin poisoning include hyperexcitability, prostration,

slow respiration, salivation, tremor, ataxia and paralysis. Chronic feeding studies resulted in increased liver weights in both males and females. In rat studies, sumithrin was completely excreted in 3-7 days (WHO, 1990). Studies have shown that sumithrin demonstrates significant estrogenicity and increases the level of estrogen in breast cancer cell, suggesting that sumithrin may increase the risk of breast cancer (Go et al., 1999).

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TRICLOPYR

USAGE

Originally developed for woody plant and broadleaf weed control along rights-of-way and on industrial sites, triclopyr is also used in forest site preparation, replacing the banned 2,4,5-T. Dow registered triclopyr in 1973, and several formulations are now available. The triethylamine salt (Garlon 3A™) is used to control woody plants when applied to cut surfaces by means of tree injection, girdle, or stumpspray. The butoxyethyl ester (Garlon 4™) is used as a basal spray or in aerial applications. M4450™ contains a mixture of triclopyr and picloram, a restricted use herbicide with a history of groundwater contamination.

Structurally, triclopyr resembles 2,4,5-T and, like this phenoxy herbicide, mimics plant growth hormones called auxins, interfering with the normal plant growth response. It is readily absorbed through both roots and leaves, and translocates throughout the plant.

Triclopyr is on EPA's Reregistration List B. It was due to be through Phase IV, where EPA determines what data are needed for reregistration and issues Data Call In (DCI) notices to the registrants. However, EPA has missed its congressionally mandated list B Phase IV deadline of October 24, 1990 and, as of November 1990, could not say when they will meet this requirement.

TOXICITY

Triclopyr is of low to moderate acute toxicity in mammals. The rat oral LD_{50} for technical triclopyr is reported to be 630-720 mg/kg, and is higher, 2000-3000 mg/kg, for formulated products. Triclopyr and its products are reported to be slightly to moderately irritating to the skin. Of greatest concern, Garlon 3A™ can cause permanent impairment of vision. Effects on the eye can include severe conjunctival irritation, moderate internal redness, and moderate to severe corneal injury. Washing is not effective in preventing these effects. Garlon 4™ is not an eye irritant.

Subchronic and chronic feeding studies in dogs and rodents found kidney and liver effects.

Mutagenicity testing in bacterial systems has yielded negative results, although bacterial mutagenicity screens are thought to be invalid for predicting the carcinogenicity of chlorinated hydrocarbons. A dominant lethal test in rats indicated a weakly positive mutagenic effect, but no similar effect was seen in mice.

Birth defect studies on rats and rabbits showed no birth defects in pups, but the rat study reported fetotoxicity including delayed skull bone ossification. This effect may be secondary to maternal toxicity. The fetotoxic NOEL (No Observable Effect Level) in this study was 50 mg/kg, and the maternal NOEL is <50 mg/kg.

The two existing rodent cancer studies submitted to EPA are considered inadequate and new studies are required. However, the mouse study results show a statistically significant increase in benign pulmonary tumors, while malignant tumor increases were not statistically significant. An independent pathologist, Ruth Shearer, Ph.D., reviewed this data and noted that the dose levels used were 8-fold less than usually deemed appropriate for testing oncogenicity.

ECOLOGICAL EFFECTS

Garlon 4™ is extremely toxic to rainbow trout and bluegills, with LC50s over 500 ppm. Studies on mallard ducks indicate triclopyr is of low acute oral toxicity, and subchronic studies on quail and ducks also report low toxicity. There are no bird field studies.

ENVIRONMENTAL FATE

Environmental degradation of triclopyr is due primarily to photodegradation and microbial decomposition. Somewhat persistent, soil half-life is strongly dependent on specific soil type and climatic conditions. Garlon labels suggest that conifer seedlings not be planted in soil sprayed within six months, suggesting that the soil will remain toxic to conifers in that period. A Swedish study found residues persisting for 1 to 2 years, and in some cases beyond 2 years. Under favorable degradation conditions, 95°F and high moisture, Dow reports a half-life of 46 days.

The breakdown products, trichloropyridinol and trichloromethoxypyridine, are generally more persistent than the parent compound, with half-lives ranging from 8-279 days and 50-300 days respectively. The toxicity of these metabolites has not been studied.

Triclopyr is considered mobile based on its ability to desorb from soil particles and organic matter, as well as its solubility in water. While degradation is rapid in water exposed to sunlight with a reported half-life of 10 hours in 25°C water, triclopyr is stable for up to nine months, the length of the study, in the absence of light (i.e. ground or well water). Contamination of surface waters is also a concern. Runoff-monitoring studies in Oregon found residues of 6 ppb in runoff water 5 months after treatment at 3 lb/acre.

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Who We Are

Beyond Pesticides/National Coalition Against the Misuse of Pesticides (NCAMP) is a non-profit membership organization formed in 1981 to serve as a national network committed to pesticide safety and the adoption of alternative pest management strategies which reduce or eliminate a dependency on toxic chemicals. The founders of Beyond Pesticides/NCAMP felt that without the existence of such an organized, national, community-based group, local, state and national pesticide policy would become increasingly unresponsive to public health and environmental concerns.

Beyond Pesticides/NCAMP's primary goal is to effect change through local action, assisting individuals and community-based organizations to stimulate discussion on the hazards of toxic pesticides. Beyond Pesticides/NCAMP provides useful information on pesticides and alternatives to their use, topics also covered in our membership newsletters **Pesticides and You** and **Technical Report** and our free bi-monthly bulletin **School Pesticide Monitor**.

Beyond Pesticides/NCAMP believes that people must have a voice in decisions that affect them directly.

Please join with us. Together we will make a difference.

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